M07 12 $9.30
SILICON CHIP Jun 12
NDC
30/05
9 771030 266001

SILICON CHIP

JUNE 2012
ISSN 1030-2662
06
9 771030 266001
PRINT POST APPROVED
- PP255003/01272
$9.30* INC GST NZ$11.90 INC GST

Quick, easy 'n' cheap to make:

Crazy Cricket/Freaky Frog

It's probably the most ANNOYING project . . . EVER!

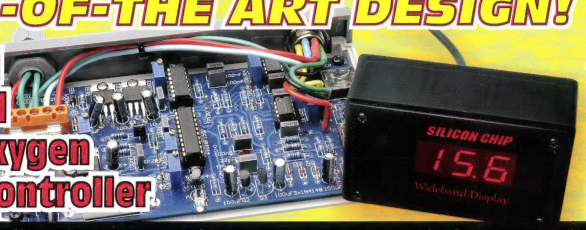
REVIEWS: We look at –

WiNRADiO *Excalibur*
9kHz – 50MHz
DDS Receiver

AGILENT 35670A
Dynamic Signal Analyser
After all this time,
it's still the yardstick!

STATE-OF-THE ART DESIGN!

Advanced
Wideband
Engine Oxygen
Sensor/Controller



LATEST MICROCONTROLLERS:

They've come a long, long way

Jaycar Electronics

Better, More Technical

Ask for our 2-page
CRAZY CLEARANCE FLYER
in-store or download from our website.
www.jaycar.com.au/JUNEclearanceAU

JUNE CRAZY CLEARANCE

UP TO 70% OFF

40A Switchmode Laboratory Power Supply

A high-powered switch mode power supply that will deliver up to 40 amps. It has a variable output voltage from 3 to 15VDC, or it can be fixed at 13.8VDC. The unit has overload, over temperature and over voltage protection.

- Large, seven segment LED display
- Size: 220(W) x 110(H) x 300(L)mm

MP-3090 ***Was $339.00***

$299.00
SAVE $40

10MHz Velleman Rechargeable Handheld Pocket Scope

A complete portable oscilloscope with a tiny size. Aside from standard scope features, it has nifty tools for measurement of RMS speaker power, display hold function, and memory storage for 2 signals. Housed in a durable rubber surround with backlit LCD display and inbuilt Ni-MH battery. See our website or in-store for full specifications.

- CRO probe and USB charge cable supplied
- 10MHz
- Rechargeable
- Size: 114(H) x 74(W) x 29(D)mm

QC-1914

$249.00

BUY BOTH FOR $400 SAVE $48

LeoStick Arduino Compatible

A tiny Arduino-compatible board that's so small you can plug it straight into your USB port without requiring a cable! Features a full range of analogue and digital I/O just like its larger cousins, and also has a user-controllable RGB LED on the board and an on-board Piezo/sound generator so you can make your board light up and play sounds without any extra hardware at all!

- ATmega32u4 MCU with 2.5k RAM and 32k Flash
- 6 analogue inputs (10-bit ADC) with digital I/O, 14 extra digital I/O pins

XC-4266

NEW
$29.95

1MHz Handheld Function Generator

A signal generator with the features of a bench top generator and a portable size! This pocket signal generator will produce sine, square, and triangle waveform signals yet it is only a little bigger than a Smartphone. Output frequency adjustment is from 1Hz to 1MHz with maximum amplitude of 8Vpp. It also has a function to shift between two frequencies over an adjustable period. With a backlit LCD, inbuilt rechargeable battery, and durable rubber surround it is an ideal instrument for testing on the go or in your workshop. See website for specifications.

- Weight: 200g
- Size: 114(H) x 74(W) x 29(D)mm

QT-2304

NEW
$199.00

LeoStick Prototyping Shield

Add your own custom parts to the LeoStick to build projects or add more I/O connectors. Fits on the top of the LeoStick and provides you a free matrix of plated-through holes for your own use.

- 64 general-purpose plated holes for your parts
- All Arduino I/O headers brought up for your use
- Includes male header pins
- Gold-plated surface

XC-4268

NEW
$7.95

KIT BACK CATALOGUE

If you can't find the kit you are looking for, try the Jaycar Kit Back Catalogue. Our central warehouse keeps a quantity of older and slow moving kits that can no longer be held in stores. A list of kits can be found on our website. Just search for "kit back catalogue".

Attention: Kit Builders

Non-Contact AC Voltage Tester with Torch

CR2032 Battery Included

Detects AC voltages from 200 - 1000V in mains outlets, powerboards or insulated wiring. It also has an LED torch and a handy pocket clip. A must for every toolbox.

- CAT III rated
- Requires 2 x AA batteries
- Size: 180(L) x 20(D)mm

QP-2271 ***Was $19.95***

$14.95
SAVE $5

To order call 1800 022 888 Price valid until 23/06/2012 **www.jaycar.com.au**

Contents

SILICON CHIP

Vol.25, No.6; June 2012 www.siliconchip.com.au

Features

12 New Microcontrollers: Feature-Laden, Fast & Furious
The microcontroller scene is on the boil, with a host of impressive products now available. Here's a brief look at what's new – by Nicholas Vinen

20 WiNRADiO Excalibur WR-G31DDC HF Receiver
"Excalibur" is the name for the latest software-controlled HF receiver from WiNRADiO. Like its namesake, it's almost magical – by Maurie Findlay

82 Review: Agilent's 35670A Dynamic Signal Analyser
An oldie but a goodie, Agilent's 35670A is virtually the industry standard for sound and vibration engineers – by Allan Linton-Smith

Projects To Build

26 Crazy Cricket Or Freaky Frog
Like the sound of crickets and frogs? You will probably revise your opinion after exposure to Crazy or Freaky, a very pesky cricket and an equally annoying frog – by John Clarke

32 Wideband Oxygen Sensor Controller Mk.2, Pt.1
Involved in car engine modifications? If so, you need to fit a wideband oxygen sensor and build this improved Wideband Oxygen Sensor Controller to check that your engine is not running too lean or too rich – by John Clarke

58 Mix-It: An Easy-To Build 4-Channel Mixer
Want to mix two or more audio signals together? This 4-channel mixer might be simple to build but its performance lacks for nothing! – by Nicholas Vinen

74 PIC/AVR Programming Adaptor Board; Pt.2
Our new programming adaptor board works in conjunction with an ICSP to program most 8/16-bit PIC and 8-bit Atmel AVR microcontrollers. This month, we describe the construction and show you how to use it – by Nicholas Vinen

Special Columns

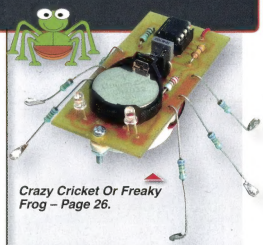
44 Serviceman's Log
Off on yet another wild goose chase – by the Serviceman

68 Circuit Notebook
(1) Tank Water Level Circuit With Hysteresis; (2) Really Simple Garage Door Monitor; (3) 433MHz Remote Lamp Switching; (4) Optical Tachometer Uses Photo-Interruptor; (5) Accurate Clock Uses Maximite & Garmin GPS Module; (6) Engine Hours Counter

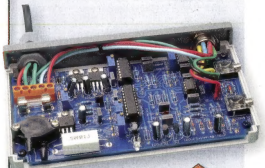
90 Vintage Radio
John de Hass & his Philips vintage radio collection – by Rodney Champness

Departments

2 Publisher's Letter
4 Mailbag
57 Product Showcase
97 Order Form
98 Ask Silicon Chip
103 Market Centre
104 Notes & Errata

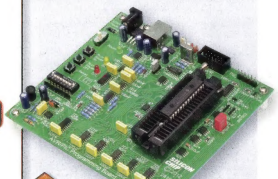


Crazy Cricket Or Freaky Frog – Page 26.



Wideband Oxygen Sensor Controller Mk.2, Pt.1 – Page 32.

Mix-It: An Easy-To-Build 4-Channel Mixer – Page 58.



PIC/AVR Programming Adaptor Board, Pt.2 – Page 74.

SILICON CHIP
www.siliconchip.com.au

Publisher & Editor-in-Chief
Leo Simpson, B.Bus., FAICD

Production Manager
Greg Swain, B.Sc. (Hons.)

Technical Editor
John Clarke, B.E.(Elec.)

Technical Staff
Ross Tester
Jim Rowe, B.A., B.Sc
Nicholas Vinen

Photography
Ross Tester

Reader Services
Ann Morris

Advertising Enquiries
Glyn Smith
Phone (02) 9939 3295
Mobile 0431 792 293
glyn@siliconchip.com.au

Regular Contributors
Brendan Akhurst
Rodney Champness, VK3UG
Kevin Poulter
Stan Swan
Dave Thompson

SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 003 205 490. ABN 49 003 205 490. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Printing: Hannanprint, Noble Park, Victoria.

Distribution: Network Distribution Company.

Subscription rates: $97.50 per year in Australia. For overseas rates, see the order form in this issue.

Editorial office:
Unit 1, 234 Harbord Rd,
Brookvale, NSW 2100.

Postal address: PO Box 139,
Collaroy Beach, NSW 2097.

Phone (02) 9939 3295.

Fax (02) 9939 2648.

E-mail: silicon@siliconchip.com.au

ISSN 1030-2662
Recommended and maximum price only.

Publisher's Letter

What's next on the automotive wish list?

Recent road trips have had me thinking about what could be improved in modern cars, in terms of safety and ease of driving. While features such as keyless entry and starting, Bluetooth and USB connectivity and DVD screens for the rear seat passengers undoubtedly have their merits, they do little for road safety. Perhaps I should qualify that; on a recent long trip with two rambunctious grandsons, I have to admit the DVDs were very good for keeping them entertained (and blissfully quiet!).

Self-parking and adaptive cruise control, pedestrian detect, collision avoidance and headlights which point around corners are all good too, although most are rather expensive at the moment. They will undoubtedly become cheaper as they filter down to a wider range of cars. But none of these really help with everyday ease of driving or road safety. Or if they do, they are not along the lines that I am thinking.

What is the biggest problem with modern cars? All-round vision is the answer. All cars have their driver blind spots but modern cars seem to be getting worse. The biggest offenders are so-called SUVs which seem to be very popular with families; not because they can go off-road but because they are seen to be rugged and supposedly offering greater safety in a collision. Well, if you equate "heavy" with "rugged" then the bigger SUVs certainly fit into this category but it does not necessarily mean greater safety in a collision, as evidenced by ANSCAP ratings.

Paradoxically too, while SUVs are higher off the road than conventional sedans, giving a better view of the road ahead, they are notoriously difficult to see out of when parking. So much so that many SUVs now have optional rear-view cameras – so that you can see what's behind the vehicle! Part of this problem though is because the rear window in so many of these vehicles is too small. The stylists have sacrificed vision to styling. That complaint also applies to many sedans and hatchbacks as well, with some having ludicrously small rear windows and thick pillars. And of course, many cars also have heavily tinted windows.

Which begs the question: if rear visibility on modern cars is so poor, why aren't rear-view cameras a standard feature? Taking the idea a bit further, why not simply get rid of the rear view mirror altogether? They seldom give a full view of the rear window which itself is often partly obscured by head rests and assorted stuff on the parcel shelf. External rear view mirrors are also problematic, with those on the passenger's side being convex and so giving a wider but distorted view. And of course, external rear view mirrors must inevitably increase the overall drag of the vehicle.

So why not dispense with rear view mirrors altogether and replace them with three cameras? Carefully placed, they could eliminate all blind spots at the rear.

There would be other advantages as well. It would enable the rear window and rear quarter windows to be eliminated. In hot climates like Australia this would mean far less heat transmission (via glass). As well, since glass is heavy, it could mean a reduction in weight while making the cabin stronger. Finally, it would mean the end of that bane of night driving, being blasted by bright headlights from the rear. I am assuming here that video processing of the camera video signals would overcome overload problems.

In case the concept of a vehicle with no rear window seems too radical or impractical, there are precedents. For a start, trucks don't have rear windows or if they do, they are obscured by the load. Second, some concept vehicles have been produced with cameras and no rear window. While they may have looked odd, the concept could certainly be made to work. What do you think?

Leo Simpson

SIOMAR
Battery Engineering

IRON PHOSPHATE

Lithium Iron Phosphate (LFP) is a special kind of rechargeable lithium battery that addresses the 4 major issues with current lithium technologies: Safety, Life, Power, and Environmental Friendliness. The chemistry has similar charge requirements to lead acid batteries and can therefore be more easily integrated into many lead acid applications than other chemistries.

SAFE

Lithium Iron Phosphate technology is an inherently safe battery chemistry "the safest lithium battery on the market" as shown repeatedly by independent data generated by the Department of Energy, UL, UN, Sandia National Labs and other agencies. The cells pass UN/DOT (UN38.3 transport safety testing) requirements with NO circuit board protection. This is not possible with traditional lithium chemistries.

LONG LASTING

Traditional Li-ion chemistries already typically last 5 years or 500 charge / discharge cycles before the AH capacity tapers off to 80% of what it was when the battery was new. This is a league above lead acid batteries which age dramatically with increasing temperature and it is even better than NiCd and NiMH. Lithium iron phosphate is better still, achieving up to 2000 charge discharge cycles.

POWERFUL

Cells can be optimized for long life, low or high temperature operation or high current without dramatically affecting service life. The LFP300HPS (90AH) cell can deliver over 4,200 Amps. Lithium phosphate cells can now meet even the most demanding application requirements — from starting a locomotive to powering an F1 racer, or cold starting a tractor at -20F.

CLEAN

Lithium Iron Phosphate can replace outdated battery chemistries like Lead-acid, NiCd, NiMH. They are designed to offer extremely long cycle life, high energy capacity, outstanding power performance, and quick charge times, while simultaneously being environmentally friendly.
These batteries use no harmful heavy metals and can be recycled. Use of phosphates in the system architecture reduces environmental concerns in all stages of the battery's life cycle. And given their long lasting nature, wearing one of these batteries out takes a lot longer than most other batteries in the first place.

3.2V
50AH

3.2V
90AH

12V
10AH

24V
19AH

For more information, contact

SIOMAR BATTERY ENGINEERING

Phone (08) 9302 5444 or email mark@siomar.com

www.batterybook.com

Siomar Batteries design and custom make portable Power Solutions

MAILBAG

Letters and emails should contain complete name, address and daytime phone number. Letters to the Editor are submitted on the condition that Silicon Chip Publications Pty Ltd may edit and has the right to reproduce in electronic form and communicate these letters. This also applies to submissions to "Ask SILICON CHIP" and "Circuit Notebook".

12V lighting in houses must be properly designed

In the Mailbag pages of the April 2012 issue, Gordon Drennan asks if it's a crazy idea to disconnect the lighting circuit from his home switchboard and connect it to a 12V DC supply, to run LED lights in place of the existing 230VAC lights. I think the idea borders on crazy and should not be attempted.

I do agree with your comments regarding a 12V DC grid installation in the house for powering not just lights but also 12V appliances. Such a system has been successfully incorporated into caravans for at least 15 years and there is no reason why it could not work in homes. But it needs to be properly designed with correctly rated and protected cable and switches. You can't just shoe-horn it into your existing house wiring without consequences.

I don't believe that LED lighting technology has yet become as cheap as Gordon states. The Oatley Electronics lights that he refers to sell for $6 each and are a driver and LED kit which would not be an effective replacement for his room lights. LED globes which may suit his requirements retail for approximately $40 each.

SILICON CHIP comments that there are two problems using existing wiring on 12V DC rather than 230VAC – switch and wire corrosion and arcing/fusing of switches. I don't entirely agree with the solution given. A suitable DC circuit breaker would protect against a short circuit but would not prevent arcing and rapid destruction of the AC-rated switches each time they are turned on or off.

I can think of several more reasons not to use the existing lighting circuit. Lights aren't the only items connected to the lighting circuit. As well as lights there could be ceiling fans, combined exhaust/heat/light fans, dimmers, PIR sensors and most importantly, hard-wired smoke alarms. Upon disconnection of the lighting circuit from the mains none of these will operate, with possible disastrous effects in terms of the smoke alarms.

Cable used in lighting circuits is 1mm^2 or 1.5mm^2 and they are usually protected by a 10A circuit breaker. These circuit breakers are selected to match the current carrying capacity of the cable used. This current carrying restriction means that not very many 12V LED lamps could be wired into each circuit. For a 10A circuit, you could only have 120W of LED lighting. Count the number of lights in your home. Would this be enough?

Voltage drop is another factor to be considered. The voltage dropped by say 200+ metres of 1mm^2/1.5mm^2 cable from a 12V DC source would be substantial and I doubt that there would be sufficient voltage left to run many LEDs.

Although I agree with the concept I can't agree with the proposed implementation. I hope no-one has attempted to try it.

David Anderson,
Pottsville, NSW.

Hearing aid satisfaction

I would like to thank you for the article "Australia Hears . . . And So Do

LED replacement lamps work well

I have recently moved about 80km south of Sydney. The house was full of 50W halogen down-lights and had five halogen spot lights outside.

Wanting to combat rising power bills (as does everyone else), I replaced most of the indoor lamps with LED replacement globes; always three are connected to a switch-dimmer combination. About 50% are GU10 230VAC while the rest are MR16 12VAC/DC. The 230VAC version works faultlessly with the dimmer but the 12V lamps flickered.

Investigating this, I found three different transformers were installed and of course, these were not compatible with LED lamps.

I consulted various people including the supplier of the LED lamps in Sydney and operators of lighting shops and was dismayed with the lack of knowledge of LED lighting – so much so that I replaced the 12V versions with 230VAC versions and did away with the transformers.

I now know that only transformers especially designed for LED lamps can be used. Why was I not told this by all those experts who should be on top of this subject? After all I can't be the only one wanting to reduce power bills in older houses.

One lighting shop operator advised me not to install LED lamps as a halogen 50W lamp only costs about 50 cents to run per evening (times about 12 lights in the living room!). Another source said I need a dimmer, switch, transformer and a driver to run LEDs. Everyone else had not heard about drivers!

Another source of trouble I have is radio reception. We are able to receive Sydney stations like 2GB and 2EA but with some interference. When any one of the dimmer-controlled lights is turned on, the interference makes it impossible to receive radio, except the local ABC station. No-one has any suggestions of how to overcome this interference problem.

Would it be possible for SILICON CHIP to run a detailed article on LED conversions? It would make it easier to comprehend the complexities and the costing before one starts purchasing parts.

Hans Moll,
Bowral, NSW.

I" in the July 2011 issue. I have a hearing loss due to industrial deafness. It did not meet the 10% or greater loss as defined by Workcover but was enough that my wife would complain about the volume of the TV or radio. Also, I had problems talking to people, even one on one where I needed them to repeat things.

Your article inspired me to purchase a pair of LOF hearing aids and the programming software aids from Blamey & Saunders Hearing, which has been one on the best investments I have made. I ordered the hearing aids around 6pm on the Friday and the hearing aids arrived the following Tuesday morning, fully programmed with my audiogram. So I was wearing them as soon as the box was opened and batteries installed.

After installing the software on a computer I did go through the normalisation part of the program to set up the hearing aids to my comfort levels but that was all that was required. Since having the hearing aids, I've been in crowded environments with lots of people talking and found them to function very well.

One notable time was recently when meeting a friend in a retirement village, where they have happy hour. I commented that not many people were wearing hearing aids as I could only see one person in the crowd of around 40. My mate said that a lot of them do have hearing aids but don't wear them to this sort of event as they don't help, as all the noises are amplified. I had no such problem even talking to people a few metres away.

The only problem I've had is forgetting to take them out before having a shower but I am now getting into a routine; this shows how comfortable they are to wear. The water has not caused any problems, the free water was wiped off and then the hearing aids put into the drying jar overnight,

Excessive sound levels in cinemas is unfortunate for the non-deaf

I totally agree that there is no need for the sound level in cinemas to be as loud as it is. I think that part of the problem is that management is catering for generation "Y" which, as we are all aware, are suffering significant hearing loss from all that "pubic enema" they call music. They have impaired their brain function by having it constantly pumping directly into their ears via powerful MP3 players and high-powered car stereos.

Unfortunately for the rest of us whose hearing may have survived pre-OHS days, cinema volume can be intolerable. I do not know why there has not been the forethought to install compressor/limiters in the signal path to compress the dynamic range, like we did when I was mixing for bands in the 1980s.

I can only surmise that high-powered amplifiers and matching speakers are so affordable now that they feel that any sort of compression is not necessary. As well as blowing people out of their seats, they may think it might be an essential "part of the cinema experience".

Greg Johnson,
via email.

Emergency Alert System
Works with any phone device – no app needed

1 **If you need assistance FAST!**

Press and hold down the 5 key on your phone

2 **Your phone dials our system which then rings your Call Group**

Everyone's phone rings at the same time. The first person to answer is connected.

3 **If needed, they can bring Triple Zero into the conversation without breaking contact.**

Ideal for:

- People living independently
- Managing disability
- People with medical conditions
- Isolated workers
- Non-English speaking people
- Children & teenagers

Test it FREE on-line – only takes a few minutes to set up.

Assure Connect™
www.assureconnect.com.au

Enquiries 1300 968 841
or email enquiries@redbutton.com.au

OCEAN CONTROLS
Helping to put you in Control
Control Equipment

Industrial Serial Server The GW51C is a gateway for Ethernet (TCP/IP) and RS232/RS485/RS422 serial communications. It allows almost any serial device to be connected to a new or existing Ethernet network.
ATO-110 $199+GST

Heavy Duty Relay Card Fitted with 2 20A relays this card can be configured to switch a DC motor between forward-stop-reverse.
KTA-272 $49.00+GST

LeoStick Arduino The LeoStick is designed to be functionally similar to the upcoming Arduino Leonardo Plugs into the USB of your PC
FRA-016 $27.25+GST

Wet/Dry Thermometer Probe. Fitted with PT100 sensors these probes can measure humidity and temperature in high humidity situations.
CMS-121 $299+GST

Industrial Flashing Light Tower Flashing LED multi-level signal light has Red, Yellow, Green lights and a Buzzer. Powered from 24VDC the lights flash at approximately 1Hz.
HEL-022 $64.95+GST

Tachometer/Line Speed/Frequency Meter This 5 digit meter has a 4-20mA output signal and RS-485 Modbus communications. 24VDC or 230VAC powered
ALT-080 $249.00+GST

Trip Alarm A programmable controller with a 0-10V/4-20mA input, a 3 digit display and 2 relays providing on/off control/alarm with or without pulse mode. Use it to control tank levels, pressures etc.
CMC-020 $149.00+GST

Contact Ocean Controls
Ph: 03 9782 5882
www.oceancontrols.com.au

Mailbag: continued

Economics of solar power

I would like to comment on the economics of installing solar panels, from the perspective of a user. Five years ago, I installed a 1kW solar system which cost $12,000. The government chipped in $8000 so the system cost to me was $4000. I live in Melbourne and have a north-facing roof. Each year it generates 1200kWh of power. Over the last two years I expanded the system to 3kW total at an additional expense of $4000, so I now generate 3600kWh per year.

As I use about 3600kWh per year, I am now energy-neutral. However, since I only generate during daylight hours, 66% of the power I generate (2400kWh/year) is returned to the grid. Origin Energy are currently my supplier and offer a premium feed-in tariff of $0.66/kWh which is worth $1600 per year. The remaining 33% that I generate (1200kWh) saves me the $0.32/kWh I pay for power.

This is worth $384 so the total saving is nearly $2000 per year. Thus the payback period for my $8000 expense is around four years. Last month, I got a $620 refund cheque for the nine months' generation.

The cost of solar panels has dropped from $5 per watt in 2008 to around $1 per watt today. You can now buy a 3kW system for $4500 installed. The tariff for power fed back to the grid (FIT) varies from state to state but is now lower than the my "Premium FIT" rate. It varies from $0.33/kWh nett in Victoria to $0.20/kWh gross in NSW (gross is for total solar power generated).

Nett power is calculated on an instantaneous basis so during the day you are credited whenever you generate more than you use; nett is not affected by power used at night.

Many power supply distributors insist on solar-enabled houses being on "Time Of Use" metering which has a high rate ($0.27/kWh) during the day and a low rate ($0.11/kWh) at night and weekends. Others offer fixed rate tariffs (eg, $0.20/kWh). I have calculated my bill using either scheme and both systems make similar returns due mainly to low "Time Of Use" rates all weekend.

A 3kW system using my usage profile in Victoria with 3600kWh gross generation (2400kWh nett + 1200kWh excess) returns $792 + $324 = $1116 per year. The payback period is about four years.

With the introduction of the Carbon Tax in July, the cost of electricity will increase significantly so the payback period will be even shorter. To future-proof yourself, I recommend that you install enough solar power to cover your usage.

To calculate size: in Victoria, divide yearly consumption in kWh by 1.2 to get the total system size in watts. In SA and NSW, divide yearly consumption by 1.3 and for Queensland divide it by 1.5. System size is typically 3kW in Victoria and 2.5kW in Queensland.

Peter Kay,
Dromana, Vic.

which has a bag of desiccant beads (supplied with the initial purchase of the hearing aids).

The only maintenance that needs to be done is to change the batteries (which last just over 1½ weeks) and clean wax from the tubes every now and then. My experience has motivated me to send this note, as I would recommend these hearing aids to others with hearing loss. I don't believe you could get a better hearing aid set at any price.

Ralph Burrow,
Werribee, Vic.

Motor Speed Controller is now main-stream technology

Firstly, let me congratulate SILICON CHIP on the Induction Motor Speed Controller project (April & May 2012). This is now certainly a main-stream technology.

I thought I'd share with you and your readers some of my experiences with IM (induction motor) drives for electric cars (EVs) over the past 40+ years. Developing a fascination for EVs in the 1960s, I managed to scrounge (from a disused electric milk-cart) a

DC motor and various other bits that I put in place of the engine and gearbox in a small car. Using "dead" batteries from the local garage, I managed to get enough range to drive a few kilometres.

That was enough to whet my appetite and I set about thinking how the resistance-controlled drive system could be improved. Certainly, DC choppers were beginning to be talked about but the idea of using a lighter and much cheaper squirrel-cage induction motor was appealing. But how do you drive an IM from a battery (DC)? Nobody I spoke with in the motor industry had much of a clue then. However, academic papers describing the principles of inverter-fed IM drives were beginning to appear in the USA and Europe.

The silicon controlled rectifier (SCR) had only been invented some 10 years before but was now becoming available with a high enough power rating for an EV IM drive. Getting the circuitry working for the forced commutation system required by the SCRs required a bit of trial and error but eventually the system worked well enough to drive a converted vehicle that was registered for road use and used for commuting between Newport and Manly (Sydney suburbs) for a time.

The next phase involved fitting a Bedford delivery van with an IM drive at the Tasmanian College of Advanced Education in the late 1970s. There were no transistors available at that time to handle the power required (250V, 400A), so the only practical option was to use force-commutated SCRs again. The drive waveforms were provided by a Motorola 6800 microprocessor taking inputs from accelerator and brake pedals, forward/reverse selector and various other sources. Having to program in machine language was rather laborious, particularly for calculations such as a maths division routine to calculate the varying voltage/frequency relationship required for optimum motor performance.

At the end of my time in Tasmania in 1979, I drove the vehicle from Hobart to Sydney, a road distance of some 1200km. With the aid of a trailer-mounted generating system providing 6kW, a daily range of up to 200km was achieved. Stops at about this interval were made at motels where the batteries were charged overnight.

The last stage of my work in IM drives took place at Sydney University during the 1990s. By this time, high-powered IGBTs (400V, 400A) had become available. Microcontroller development had also moved forward and a controller from the Intel 8096 series seemed to be a good choice. Programming was much easier, this time in assembly language that for a maths divide routine, for example, a command div x, y replaced more than 60 machine code instructions used earlier in the Motorola 6800.

The drive was fitted to a Holden Rodeo that was used for several years as a general runabout vehicle. Road performance was quite adequate for general city/suburban driving, speeds of over 80km/h being readily achievable. Although limited by the use of lead-acid batteries but helped by regenerative braking, a working range of some 75km was achieved on one charge. With its on-board battery charger the vehicle could be plugged into a standard 240VAC outlet whenever parked so a daily working range of well over 100km could be achieved.

It's satisfying to see that quite a number of EVs being produced today by the automotive industry are using induction, or more recently, "brushless DC" motors supplied by inverters, basically of the same type but now making use of the latest technology of integrated power circuits and advanced microcontrollers.

I congratulate Andrew Levido for his achievement and his lucid description of the IM and its characteristics. The design looks so simple and elegant from a hardware point of view, with all the complexity embodied in the microcontroller software. For some time I've thought of building a controller for my 3-phase lathe motor and getting acquainted with the PIC family of microcontrollers. This project will allow me to achieve both.

David Gosden,
Bundeena, NSW.

Induction Motor Controller needs braking for lathes

I read with great interest the article on the 1.5kW Induction Motor Speed Controller. I have been an avid reader

Now Available
Electrostatic Speaker Panel Evaluation Kit (ESLK-440) from
Reality Technologies

With over 70 years combined experience in ELS design and manufacture, we are able to bring you the spectacularly high quality of electrostatic sound, for the first time reproducible in volume at low cost, and only 8mm thick!

This kit is suitable for DIY speakers or for use in consumer electronics products - Suggested applications include hi-fi, home theatre or integration with flat-panel televisions.

This kit includes 2 of our framed, high quality 5th-generation electrostatic panels with stands and all the driving requirements - cables, power supplies and transformers.

Supplied in a padded carry case.

$495 including GST and 12 Month warranty.

Speaker Panels are available OEM for consumer electronics development - we can work with you to create custom sizes to suit your application - call us for details.

Reality Technologies
PH: 03 8581-7638
www.reality-design.com.au

ER Audio
PH: 08 9397-6212
www.eraudio.com.au

DYNE
INDUSTRIES PTY LTD
Now manufacturing the original ILP Unirange Toroidal Transformer

- **In stock from 15VA to 1000VA**
- **Virtually anything made to order!**
- **Transformers and Chokes with Ferrite, Powdered Iron GOSS and Metglas cores**
- **Current & Potential Transformers**

DYNE Industries Pty Ltd
Ph: (03) 9720 7233 Fax: (03) 9720 7551
email: sales@dyne.com.au
web: www.dyne.com.au

Mailbag: continued

What was the benefit of banning incandescent lamps?

Having a need for a couple of high-power motor controllers, I burrowed my way back to the April 2007 edition of SILICON CHIP and found the article I wanted. I also happened to re-read the Publisher's Letter entitled, "Banning incandescent lamps will have a negligible effect on greenhouse gasses".

Having had five years of this nonsense now, I wonder if the Government could tell us exactly how much "greenhouse gas" has been saved on the planet as a whole but more importantly, tell us how much mercury has been bulldozed into landfill sites when the fluorescent "dead" ones have been thrown out and not recycled.

I guess it goes to prove that the Liberals were just as idiotic as Labor in the "global warming" – sorry, "climate change" – scare-mongering. The only up-side to the Carbon Tax that is going to save the world (the one we were promised we would never have under this Government), is that it should ensure the total demise of Labor at the next federal election.

John Brown
Bibra Lake, WA.

of this magazine since 1990 and was very pleased to finally see this project in SILICON CHIP. Well done! However I must raise a few points on its intended use. While I'm sure the most likely use for this controller will be dedicated use on pool pumps and the like, I do wonder about its suitability for use on all but the very smallest workshop machinery. As a fitter and turner by trade I have just gone through the exercise of fitting my own machines with 3-phase motors and commercial VFDs and would like to share some of the pitfalls I encountered.

Typically, lathes and milling machines present the motor with a large inertial load; lathes especially. In order not to trip the unit out in an over-voltage or over-current fault, the VFD must be programmed for a very slow start-up and ramp down time. However quite often it is desirable to start, and in particular, to stop the machine as quickly as possible. If allowed to trip out on over-voltage during a ramp down, the machine can run on for tens of seconds if there is no mechanical brake. This is particularly important in an emergency situation where the machine needs to be brought to a halt as quickly as possible.

Aside from the safety standpoint there are a few machining operations that require the machine to be brought to a halt (and often then put into reverse) as quickly as possible. The main one being the threading operation and in particular when cutting metric threads on a machine fitted with an Imperial lead screw (or vice versa), as in this situation the half nuts cannot be disengaged at the end of a cut.

This is a particular problem with small machines fitted with single-phase induction motors as even when switched directly into reverse, they will continue to spin in the same direction!

The solution to this problem is of course a 3-phase motor and a VFD fitted with dynamic motor braking. As you would know, dynamic motor braking involves using a large suitably-rated braking resistor which is switched into the DC bus during an over voltage event to dissipate the inertial energy supplied from the motor. This allows the VFD to ramp down in speed much faster and still avoid an over voltage fault.

In my experience, a VFD that is not fitted with dynamic braking is pretty much useless on lathes and to a lesser extent on mills. Without dynamic braking, a large load in a heavy 4-jaw chuck of a lathe going at 1000 RPM will often trip a VFD into over-voltage during ramp down, even with a long ramp down time.

Does the designer have any plans to include dynamic braking into this or perhaps a follow-up design?

Lee Trengove,
Carina, Qld.

Comment: as you say, the main attraction for the Induction Motor Speed Controller will be with pool pumps. Braking could be incorporated but it would essentially mean a new design.

Depending on the success of this published design, we may consider a design with braking in the future. However, it will inevitably be more expensive.

Induction Motor Speed Controller peak current concern

It was with more than a little interest that I have read your first article on the 1.5kW Induction Motor Speed Controller project (April 2012). As I have only seen the first part of this design, I am hesitant to make the following comments. However, some fundamentals are apparent and beg closer scrutiny. You state that the circuit is rated for a maximum output of 8.5A. That rating is well within the capabilities of the ST power bridge. However, your input circuit seems inadequate for this role.

The mains input is rectified and fed into three paralleled 470µF capacitors. With this arrangement, where the capacitors feed an output of 8.5A to the load, the input currents become rather complex, as the capacitors are only charged near the peak of every sinewave. Indeed, you cover this very subject in your article on page 36 of the same issue.

Accurate calculations are impossible without additional data. However, "back of envelope" estimates point to mains input currents of about 35A peak and 14A RMS. Thus the 230VAC input wiring must handle a minimum of 14A RMS/35A peak, as do the rectifiers, input fuse, thermistor, EMI filter etc. Yet your input fuse is rated at 10A and you specify a maximum input current that the venue and the sound department regularly check the sound pressure levels in a number of areas. What you find is that although the music may peak at 90-95dB, when it is just speech it probably sits at around 75-80dB. As such, the average exposure is below that which is required to be adhered to.

Having said that, on other shows (such as Rock Of Ages) it is not uncommon for the level to go above 100dB.

Gerard Hook,
Box Hill North, Vic.

Leo Simpson comments: your reaction to the sound level in that show as being quite reasonable reinforces my view that sound engineers have become de-sensitised. It certainly did get loud, whether or not "for effect".

Loud sound in cinemas & theatres

In regards to the Publisher's Letter on loud sound in cinemas and theatres (March 2012), I thought I would just make a comment from the point of view of a sound engineer.

I have actually been to "Love Never Dies" and I was with the sound crew for two performances. One thing not many people realise is that, although the sound engineer is the one running the show, all the levels are pre-recorded and all decisions on level are made by the director, sound designer and producer. So it is not so simple as "turning it down".

I find it interesting that Leo found "Love Never Dies" loud, as I found it to be quite reasonable, only getting loud for effect.

In regards to noise limits, I know

Mailbag: continued

Noise exposure should be displayed

It amazes me that in this day and age when hearing experts are completely aware of the sound volume and exposure durations that cause hearing loss that there are not strict controls over exposure times. Maybe it's the anti "nanny state" idea but surely it should be fairly simple to create an "RDI" (recommended daily intake) and require devices and venues that "create" sound to publish their adherence to these guidelines.

Theatres, live shows and other "fixed duration" type environments should be required to note the RDI percentage of sound exposure. "Variable duration" environments should be required to display an RDI percentage over, say, a 4-hour period.

Devices such as iPods and the like should have the estimated hours of exposure displayed as the volume setting is adjusted and then the device should monitor the actual sound level and continuously update the percentage of RDI used on the display. There's nothing new or complicated here; most devices already have the necessary hardware, they just need the software.

In my view, once 100% is reached the devices should simply turn off until the 24 hours is up. In reality, such "looking after our own good health" features are not available already, probably, because (a) if the device didn't turn off at 100% the manufacturer would open themselves up to lawsuits and (b) if it did, no-one would buy their product.

Once everyone was required to publish the RDI they expose their patrons to, they would probably also quickly adjust their volume controls. A table of volume versus level and exposure risk can be found at **http://www.etymotic.com/technology/ihp.html**

Note that this table is weekly; not daily. It makes sobering reading as I find the recommended exposure levels to be considerably lower than what we normally experience in any "event" environment. I leave you with this as an "answer" to those who try to lay any of the blame on "sound engineers" (from **http://www.digital-recordings.com/publ/pubear.html**).

There are common misconceptions about "sound engineers" and sound reinforcement. The assumptions are they know what they are doing when adjusting sound and they adjust to safe levels. Both are not true.

Most so-called "sound engineers" (about 99%) have no formal training in acoustics and sound reinforcement. The operation of sound systems does not require any licence or qualifying exam, yet the operators are in control of a potentially very damaging form of energy.

Most sound engineers (about 99%) don't use sound level meters to measure intensity. Instead they judge the sound level "by ear"; an inexact procedure even if we assumed they had no hearing loss. Research in Halifax night spots showed in 1986 that a risk of hearing loss for patrons was present in 64% of all tested locales during one hour of exposure and in 95% during four or more hours of exposure (a typical evening at a night club lasts four hours).

Mark Eynden,
Mount Waverley, Vic.

rent of 8.7A. This is one reason that quality commercial products in this power range will invariably include an input PFC stage.

There are additional consequences to this. The DC voltage at the 470µF capacitors will include significant ripple. With the values shown, this ripple will be somewhere near 30V peak-peak at 100Hz. This ripple will ultimately be transferred to the output, resulting in a significant 100Hz modulation of the motor current; not good for the motor!

Additionally, we must also consider

Kinsten Presensitized PCB & associated products

IN STOCK NOW!

- Single Sided Presensitized PCBs
- Double Sided Presensitized PCBs
- Fibreglass & Phenolic
- UV Light Boxes
- DP50 Developer
- PCB Etch Tanks, Heaters & Aerator Pumps
- Thermometers
- Ammonium Persulphate Etchant
- PCB Drill Bits (HSS & Tungsten)

WILTRONICS
38 Years Quality Service

For full range, pricing and to buy now online, visit
www.wiltronics.com.au
Ph: (03) 5334 2513 Email: sales@wiltronics.com.au

the effect of all the AC currents on the 470µF capacitors. They will bear the brunt of it all. Again, there is insufficient data for accurate numbers but a good estimate (under full load conditions) for the total capacitor ripple current is 16A RMS. Perusal of industrial grade capacitor data reveals that this number is likely to exceed their maximum ratings.

Lastly, I don't think the power supply authorities will be impressed to find that this sort of equipment is connected to their grid, again for the reasons you state in your article on page 36. As an engineer with several decades' experience in the design of power electronic equipment, I simply wanted to bring these issues to your notice.

Name & address supplied but withheld.

Comment: your back of the envelope calculations don't add up. If it was true that the unit pulled 14A RMS from the 230VAC mains then the input power would be around 3kW and the efficiency would be around 50%, with at least 1.5kW being dissipated in the box when driving a 1.5kW load. The case would melt!

You are possibly making a mistake in assuming that the 8.5A RMS maximum single phase load current means that the unit is supplying 2kW. It is not; the maximum power output is 1.5kW (you have to allow for the power factor of the motor load). Nor is there a large 100Hz component across the motor, as can be seen from the scope grab on page 20 of the article.

As for the power authorities, they may well be unhappy but the article on pages 36-37 of the same issue indicates that it is a widespread problem with switchmode power supplies being ubiquitous.

***The designer, Andrew Levido, has made additional comments, as follows**: a typical single-phase 1.5kW (shaft power) motor draws around 8A at 240V AC, about 1800W (ie, about 80% efficiency and allowing for power factor). Ignoring losses for a moment, at an electrical output power of 1.8kW and 240VAC mains, the average DC bus current will be 1800 ÷ (√2 x 240) = 5.3A, and the RMS input current will be 1800 ÷ 240 = 7.5A (I'm not sure how the reader got to 14A).*

Since RMS is defined in term of power, it is independent of wave shape, so 7.5A RMS is 7.5A RMS whatever the shape.

Certainly the input current will be peaky – with the peaks limited by the mains source impedance (very low), the in-rush limiter (about 0.1Ω at this current), the input filter ("less than 0.1Ω" according to the data), the capacitor ESR (0.423Ω each, so 0.14Ω for three in parallel) and any stray series impedance in the circuit wiring. This is fairly typical for a large SMPS or UPS although the electricity authorities don't like it much, as you suggest. If the reader is really worried, then a suitably-rated input inductor could be used.

Adding about 50W of losses increases the line current by 200mA and the DC current by less than 140mA, not substantively changing the above picture. There will be a significant component of 100Hz ripple on the DC link, which will produce a ripple current in the capacitors, which are each rated for 1.99A RMS. With three capacitors in parallel we have a ripple current capability 6A.

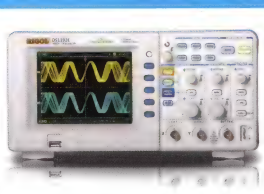
Note that there will be a component of ripple current in the capacitors related to the output current as well.

My calculations suggest that at the absolute worst case (when input and output frequencies are matched but out-of-phase by 90°) the ripple current will be 4A RMS and a typical value will be closer to 3A RMS. That said, these capacitors have a stated life of 2000 hours and so won't last forever whatever we do.

The motor may see a small 100Hz ripple component superimposed on the nominal frequency but I disagree with the reader's statement that this is "not good for the motor!". I imagine this might produce a very small torque ripple (after the filtering effect of the rotor's inertia) but I can't see how this could damage the motor in any way. This is an AC motor after all. SC

Australia's Lowest Priced DSOs

Shop On-Line at emona.com.au



Now you've got no excuse ... update your old analogue scopes!

Whether you're a hobbyist, TAFE/University, workshop or service technician, the Rigol DS-1000E guarantee Australia's best price.

RIGOL DS-1052E 50MHz

- 50MHz Bandwidth, 2 Ch
- 1GS/s Real Time Sampling
- 512k Memory Per Channel
- USB Device & Host Support

ONLY $362 inc GST

RIGOL DS-1102E 100MHz

- 100MHz Bandwidth, 2 Ch
- 1GS/s Real Time Sampling
- 512k Memory Per Channel
- USB Device & Host Support

ONLY $439 inc GST

Sydney Tel 02 9519 3933 Fax 02 9550 1378
Melbourne Tel 03 9889 0427 Fax 03 9889 0715
Brisbane Tel 07 3275 2183 Fax 07 3275 2196
Adelaide Tel 08 8363 5733 Fax 08 8363 5799
Perth Tel 08 9361 4200 Fax 08 9361 4300
email testinst@emona.com.au
web www.emona.com.au

EMONA

Microcontrollers:

feature-laden, fast and furious

The microcontroller scene is certainly on the boil, with a host of new products competing for the lowest power consumption, best performance and best value. Here is a brief look at what's new in the microcontroller world, some already available and some soon to be released...

Elsewhere in this issue we present the second and final instalment of our PIC/AVR Microcontroller Programming Adaptor board, which allows the user to program over 450 different types of microcontroller from Microchip and Atmel.

That seems like a lot – how many more microcontrollers can there be than that?

Actually, 450 is only a drop in the bucket. At one major supplier, we counted over 20,000 different micro types presently available!

Some of these are the same chip in a different package (DIP, SMD etc) but even when you take that into account, there are still thousands of different microcontrollers from scores of suppliers.

Even among the types that our readers will be familiar with, such as PICs, there has been very significant progress over the last few years.

Prices have dropped, processing power has increased and the integrated peripherals have been substantially enhanced.

Until recently, most micros had just a few analog input pins (or in some cases, none) and maybe two or three basic PWM outputs.

Newer chips can have a dozen or more analog inputs, some with built-in programmable gain amplifiers, six or more PWM outputs with advanced modes designed to drive brushless motors and Mosfet bridges, configurable serial buses capable of high speed operation and so on.

One good example is the dsPIC33E/PIC24E series. These are more or less compatible with dsPIC33Fs/PIC24Fs, which we have occasionally used in the past.

But they are substantially more powerful, running at two or three times the speed and with more advanced peripherals as standard. We'll take a look at these later in this article.

Benefits

Having said all that, even a bog-standard micro lets us do things that would be much harder with discrete logic chips. Virtually any digital circuit can be built using discrete logic but the cost and complexity can quickly become prohibitive for all but the most simple tasks.

Consider what you get when you buy

by NICHOLAS VINEN

the cheapest microcontrollers, which may be just a couple of dollars: you get thousands of logic gates whose function can be reconfigured virtually at will.

You also get dozens of digital input buffers and output transistors and usually a 10-bit or 12-bit ADC with input multiplexer, several configurable PWM generators plus some serial interfaces and other goodies.

Not only is the resulting hardware a lot easier to design but fixing a bug in software can be a lot easier than fixing hardware errors; much easier to fix a few lines of code than do a re-design of a PCB, get a new prototype, assemble and test – and hope like crazy it behaves as it's supposed to!

One example of a recent project which would have been prohibitive without a microcontroller is the 1.5kW Induction Motor Speed Controller (SILICON CHIP, April-May 2012).

This uses a dsPIC33 chip designed for motor control. It can generate three in-phase centre-aligned PWM signals with glitch-free updates. The micro also manages the motor speed so that it varies smoothly, synthesises the sinewaves with which to drive the motor windings, monitors the circuit for faults and so on.

Another example is the Maximite microcomputer, which demonstrates how much the line between microcontrollers and microprocessors has become blurred (see panel).

This small computer connects to a keyboard and VGA monitor, uses a memory card for storage and can be programmed using BASIC. It's based on a PIC32 microcontroller which has surprisingly good performance for a relatively cheap chip, at around 125MIPS (million instructions per second).

Also in this issue is the first part of our new Wideband Oxygen Sensor Controller. One of the many changes compared to the last incarnation is that we are now using the PIC16F1507, a new part from a long-running series.

While its CPU core is much the same as other PIC16s, it has more ADC channels (12), a built-in voltage reference with three selectable levels, four PWM modules, two Configurable Logic Cell modules (which can replace external digital logic ICs), a Numerically Controlled Oscillator (NCO) and a Complementary Waveform Generator (CWG).

All these features make the new Wideband Oxygen Controller simpler but more capable.

Of course, we tend to stick with tried-and-true chips when they suit the task at hand. One of the main benefits of commonly used chips is their wide availability. But in some cases, the application calls for a newer, more advanced IC.

Overleaf, we examine some of the newer and more interesting microcontrollers on the market.

Microcontrollers vs Microprocessors

So just what is the difference between a microprocessor (as found in a computer) and a microcontroller? These days, not much.

The main difference is that microcontrollers generally require less support circuitry, making them more convenient for use in embedded designs.

By contrast, a microprocessor usually needs to be connected to RAM (random access memory) and ROM (read-only memory) chips. The RAM is used as working space storage while the ROM provides the initial instructions for the processor.

Microprocessors also tend to have fairly strict supply voltage requirements to work reliably at their rated speed and they are usually designed to interface with other complex ICs which handle their input/output needs and provide for connection to a keyboard, mouse, monitor, network and so on.

By comparison, the majority of microcontrollers these days have internal RAM and flash memory for instructions.

This reduces cost and also dramatically reduces the number of pins required and hence the size and cost of the IC package. It saves on PCB space and avoids the need to route dozens or even hundreds of memory bus tracks.

Microcontrollers usually can run from a wide range of supply voltages, eg, 2.7-5.5V so they can run direct from a battery or a variety of different power supplies. Some will run from 1.8V or less while a few are designed to run off 12V or more, so that they can powered from multi-cell batteries without the need for a regulator.

Unlike most microprocessors, a microcontroller has a fair bit of on-board "peripheral" circuitry such as analog-to-digital converters, PWM (pulse width modulation) outputs, USB and in some cases Ethernet, allowing it to interface to other circuitry without the need for many additional ICs.

Microprocessor peripherals are usually limited to serial/parallel data communication with other digital ICs.

Having said all that, there is increasing convergence between microcontrollers and microprocessors.

The most powerful microcontrollers, such as those used in MP3/MP4 players, smart phones and so on, can run at 1GHz or more, access large amounts of RAM, have graphics acceleration features and so on.

In fact, they are more capable than the microprocessors that were available not much more than ten years ago.

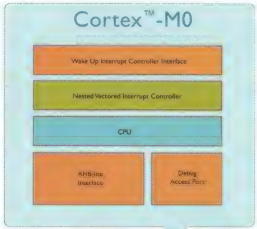
On the other hand, computer microprocessors have started to branch out into the same space.

For example, there is the Intel Atom and the AMD G-series of microprocessors. Both are derived from mainstream CPUs (central processing units) and both offer low power consumption and a high level of system integration. For instance, they have on-board graphics controllers and memory controllers. They also come in smaller, thinner packages than traditional CPUs, for use in portable electronic devices.

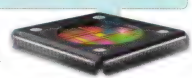
With the popularity of smart phones and portable media players, expect to see more improvements in microcontroller performance and features over the next few years.

ARM Cortex-M0

This is latest addition to the 32-bit ARM line-up of microcontroller cores. It is notable for especially low power consution figures combined with good performance.



Core power consumption is just 32µW per MHz for chips built on a 90nm silicon process, with a 1.2V core supply (peripherals consume additional power).



The Cortex-M0 has an optional single-cycle 32-bit multiplier and runs up to 50MHz, with a performance of 42 Dhrystone MIPS at full speed.

The Cortex-M0 was introduced following the more powerful M3 series and at around the same time as the M4 series. These all use the "THUMB-2" instruction set which mixes 16-bit and 32-bit instructions for improved code density, compared to the original ARM instruction set which is 32-bit only. The M0 supports a subset of THUMB/THUMB-2 to keep the core small and minimise power usage.

ARM do not manufacture the chips; they license the design to manufacturers. Chips based on the Cortex-M0 are currently available from NXP (LPC11xx and LPC12xx), ST Microelectronics (STM32M0 and upcoming STM32F0 series), Energy Micro (EFM32 ZG-series) and Nuvoton Tech (NuMicro series). These are all SMDs (surface mount devices).

The Cortex-M0+ is the same as Cortex-M0 but its pipeline has two stages rather than three, which reduces branch penalties. Chips based on this core will be made by NXP and Freescale Semiconductor (Kinetis L series).

Since these chips use the same instruction set as a large number of existing 32-bit microcontrollers, there are already many suitable compilers, debuggers and development environments. In fact, code written for Cortex-M0 processors will run on Cortex-M3 and Cortex-M4 processors without modification.

Readers interested in getting into Cortex-M0 programming might want to try the NXP LPC11U24 Cortex-M0 "mbed" embedded development board from RS components (see photo).

This has an on-board power supply and USB programming port. It breaks the SMD chip's pins out to pin headers, suitable for use with breadboards and protoboards.

Another option is the LPC1114 Cortex M0 Stamp board. Available for around 18 Euros, this small breakout board has an NXP chip with 32KB flash, 8KB RAM, an 8-channel 10-bit ADC and a USB serial port. Its I/Os are broken out to a pair of pin headers and it also has a USB bootloader and on-board power supply.

ARM Cortex-M4

The Cortex M4 is at the other end of the spectrum from the M0 and includes everything but the kitchen sink. The M4s include a single-precision floating point unit (FPU) with some DSP instructions, including 8-bit and 16-bit SIMD (single instruction, multiple data), multiply-accumulate instructions and a hardware divide unit. They also include a memory protection unit (MPU).

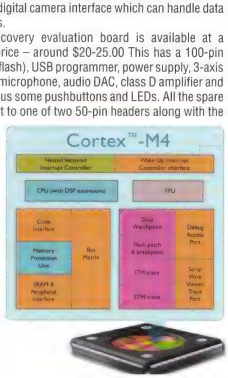
The result is around 1.25DMIPS/MHz and with speeds up to about 160MHz, M4s are capable of 200MIPS+ and can typically handle supply voltages anywhere between 1.8V and 3.3V.

In keeping with the core, Cortex M4s also typically have a rich set of peripherals. One of the best examples is the STMicro STM32F4 series. These are available in 64-176 pin SMD packages and include 12 timers with around 40 PWM channels, up to 1MB of flash memory and 192KB of RAM, up to 24 analog-to-digital converter inputs, two digital-to-analog converter (DAC) outputs, hi-speed USB On The Go (OTG), 100Mbit Ethernet, multiple serial controllers and so on.

These are among the most powerful microcontrollers available which do not require external flash or RAM. In fact they only need a handful of bypass capacitors and little else. Other useful features include a built-in random number generator, hardware checksum calculation unit and a digital camera interface which can handle data rates up to 54Mbites/s.

The STM32F4 Discovery evaluation board is available at a surprisingly modest price – around $20-25.00 This has a 100-pin microcontroller (1MB flash), USB programmer, power supply, 3-axis digital accelerometer, microphone, audio DAC, class D amplifier and USB OTG connector plus some pushbuttons and LEDs. All the spare I/O pins are broken out to one of two 50-pin headers along with the power supply pins.

Cortex M4 microcontrollers are also available from NXP (LPC43xx-series), Texas Instruments (LX4-series), Freescale Semiconductor (Kinetis M and P-series) and Energy Micro (EFM32 L-series). Of these, the Freescale Semiconductor parts are notable for their high-precision 16-bit ADCs.



Does Your Design Require Low Power Analog?

Microchip has the answer ...

Microchip offers a broad portfolio of low power analog products that support a wide variety of applications. With over 700 unique stand-alone analog products covering thermal management, powermanagement, battery management, mixed-signal, linear, interface and safety and security.

Operational Amplifiers

MCP6441/2/4

- 450 nA quiescent current per channel
- Operating voltage down to 1.4V
- Small SOT-23 and SC-70 packaging

Switching Regulators

MCP1640 Sync Boost Regulator

- 0.65V start-up voltage
- 19 µA quiescent current
- True load disconnect
- Up to 350 mA out

Low Dropout Regulators

MCP1700

- 1.6 µA quiescent current
- 300 mV dropout voltage
- Ceramic capacitor stable

Analog-to-Digital Converters

MCP342X

- 145 µA quiescent current
- Up to 18 bit resolution
- Operating voltage down to 2.7V

GET STARTED WITH YOUR LOW POWER ANALOG DESIGN TODAY!

www.microchip.com/analog

MCP1640 Synchronous Boost Coverter Reference Design (MCP160RD-4ABC)

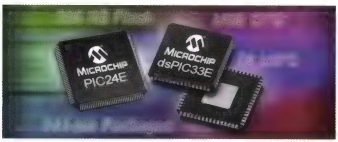
Microchip Technology Australia
Tel: (02) 9868 6733 E-mail: aust_nz.inquiry@microchip.com

MICROCHIP

Microcontrollers • Digital Signal Controllers • Analog • Memory • Wireless

The Microchip name and logo and the Microchip logo are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries. All other trademarks mentioned herein are property of their respective companies.
© 2012 Microchip Technology Incorporated. All rights reserved.

Microchip dsPIC33E & PIC24E



Microchip recently added two new, related series of 16-bit processors to their microcontroller line-up: the dsPIC33E and PIC24E series. In the past, while the PIC24 and dsPIC33 lines were both 16-bit micros, there were many differences between them. With these new lines, the features have been all but merged, giving us the best of both worlds.

The biggest difference from those earlier micros (dsPIC33F, PIC24F/H) is the much higher performance of the E-series. These can achieve up to 70MIPS at 70MHz (60MIPS/60MHz for the extended temperature range). By comparison, the dsPIC33F-series goes up to 40MIPS/40MHz while the PIC24F-series only manages 16MIPS/32MHz.

As well as having two or three internal comparators, these chips also feature the same number of internal op-amps which can either be used to give true differential ADC (analog-to-digital converter) inputs or as general purpose devices connected to an output pin. Some PIC24E and dsPIC33E chips also have a USB On-the-Go interface, which was not available for the dsPIC33F series.

These chips retain many of the useful features of the earlier series chips including a fast and flexible ADC, with 4-channel 10-bit resolution mode at up to 1.1MSPS (megasamples per second) and single-channel 12-bit resolution mode up to 500kSPS. They also add some new features such as configurable pull-down resistors on each I/O pin (in addition to the configurable pull-ups).

Both new series have the 40-bit accumulators with single-cycle multiply/accumulate instructions and hardware divide unit, as for the dsPIC33F series. In fact the only difference between the dsPIC33E- and PIC24E- series processors is that the dsPIC33Es have ECAN (Extended Controller Area Network) support.

The Motor Control (xxxMCxxx) chips in this series feature high-speed PWM modules with ~7ns output pulse resolution and a number of different modes to suit different motor types. These devices also have a Quadrature Encoder interface.

The dsPIC33Es and PIC24E are available in DIP and surface mount packages. Microchip also sell a dsPIC33E USB Starter Kit which features a surface mount dsPIC33e chip, an on-board USB programmer and separate USB connection for direct communication with the micro. It also has an I/O expansion header.

Atmel SAM3U

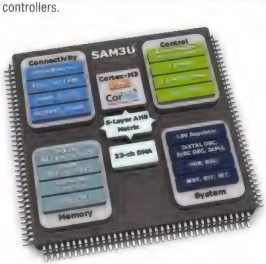
SAM3U is a series of microcontrollers based on the ARM Cortex M3. The main difference between the M3 core and the aforementioned M4 is that the M3 does not have a floating point unit (FPU).

What makes the SAM3U series unusual is on-chip hi-speed USB. This allows much higher data transfer rates than full-speed USB; 480Mbits/s compared to just 12Mbits/s.

While some other ARM-based microcontrollers have hi-speed USB controllers (eg, the STM32F4), they usually require an external hi-speed USB PHY (physical layer) chip. This increases the total cost and takes up more board space. By contrast, the SAM3U has an integrated hi-speed PHY and its cost is comparable to other Cortex M3 based parts.

SAM3U series microcontrollers operate at up to 96MHz/120MIPS. They are available with 64-256KB flash memory, 16-48KB RAM and in 100/144 pin SMD packages.

Extra features include a memory protection unit, dual-bank flash for safe self-programming, multiple low-power modes, an 8-channel 12-bit 1megasample/s ADC with differential inputs and programmable gain plus an 8-channel 10-bit ADC and up to nine serial controllers.



Texas Instruments MSP430

TI is lifting its profile in the microcontroller world with the MSP430G2 "Value Line" series of low power, low cost 16-bit microcontrollers.

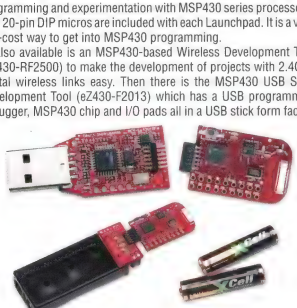
These are available in speed grades from 8MHz to 25MHz and with 1-256KB of flash memory. They have an array of optional features such as ADCs, DACs (digital-to-analog converters), hardware multiply unit, UARTs, LCD controllers, PWM outputs and so on. MSP430-series chips are available in DIP and surface mount packages.

The MSP430 series features an innovative DCO (digitally controlled oscillator) for clock generation which allows the chips to run over a large range of speeds from a low-power internal oscillator. This can wake up fast from low power "sleep" modes (around 1µs).

As one example, the MSP430G2553 has 16KB of flash and 512B RAM, runs at up to 16MHz from a 1.8 to 3.6V supply and consumes around 230µA/MHz. It has two 16-bit timers with three PWM outputs each, serial ports (UART, SPI and I^2C), JTAG, an 8-channel, 10-bit 200kSPS ADC, a real-time clock type function and up to 24 GPI/O pins (in 28-pin SMD package; 16 for the 20-pin DIP package).

The MSP430 Launchpad is a small pack with a USB programmer/debugger, 20-pin IC socket and pin headers which, in combination with a free Windows development environment, allows for easy programming and experimentation with MSP430 series processors. Two 20-pin DIP micros are included with each Launchpad. It is a very low-cost way to get into MSP430 programming.

Also available is an MSP430-based Wireless Development Tool (eZ430-RF2500) to make the development of projects with 2.4GHz digital wireless links easy. Then there is the MSP430 USB Stick Development Tool (eZ430-F2013) which has a USB programmer/debugger, MSP430 chip and I/O pads all in a USB stick form factor.



Microcontroller Glossary

ADC (Analog-to-Digital Converter): a circuit where the input is a voltage level and the output is a binary number. Allows digital circuits such as microcontrollers to sense voltage levels and measure analog signals. The resolution is specified in bits (eg, 12 bits); with more bits, it measures the voltage in smaller steps, for greater accuracy. ADCs also have a maximum sampling rate, often specified in kilosamples per second (kSPS) or megasamples per second (MSPS). This indicates how often the ADC's binary output can be updated to reflect changes in the input voltage. ADCs are often fitted with input multiplexer and sample-and-hold buffers. See also: multiplexer, sample-and-hold buffer, DAC.

ARM (Advanced RISC Machine): one of the most common types of 32-bit microprocessor/microcontroller. ARM is a processor architecture which was introduced in 1987 and has been upgraded many times since. Most ARM microcontrollers are based on the ARM7, ARM9 or Cortex designs. ARM Holdings designs the ARM core design cores and licenses them to manufacturers who then add peripherals, memory and other support circuitry.

AVR: A line of 8-bit and 32-bit microcontrollers from Atmel; the first microcontrollers to feature internal flash memory for program storage.

CAN (Controller Area Network): a serial bus standard, designed for use in vehicles, developed by Bosch.

ECAN (Enhanced CAN): a CAN peripheral which performs much of the work to implement the CAN protocol, so that the processor doesn't have to.

Centre-aligned PWM, dual-ramp PWM: a form of pulse width modulation which, unlike traditional edge-aligned PWM, does not place the rising edge at the same point in each cycle for different duty cycles. Can result in less electro-magnetic interference than edge-aligned PWM.

Clock rate: the frequency of the clock signal used to drive the CPU core. This determines the rate at which instructions are executed. See: MIPS.

Code, Instruction code: the set of instructions which tell a microprocessor or microcontroller what to do. The code therefore defines its function.

Code density: this is a measure of how much memory the instructions take up for any given task. An instruction set with high code density takes less space to store the instructions required for a given task than one with a low code density.

Core: the part of a microprocessor which loads instructions from memory and then acts on them. This is the most fundamental part of a microprocessor or microcontroller. Other parts include RAM, ROM, flash and peripherals. Also known as an execution unit.

CPU (Central Processing Unit): the main microprocessor in a computer.

DAC (Digital-to-Analog Converter): a circuit where the input is a binary number and the output is a voltage level. Allows digital circuits such as microcontrollers to control a voltage level or generate an analog signal. Resolution is specified in bits (eg, 12 bits); with more bits, its output voltage changes in smaller steps. DACs also have a maximum sampling rate, often specified in kilosamples per second or megasamples per second. This indicates how frequently the DAC's analog output can be updated. See also: ADC.

Microcontroller Glossary. . . continued

DCO/NCO (Digitally-Controlled Oscillator or Numerically-Controlled Oscillator): an oscillator where the frequency can be changed by the software. Typically used to generate the instruction clock, so that the software can switch between high-speed and low-power modes.

DIP (Dual In-line Package): the package used by virtually all through-hole microcontrollers. The chip is encapsulated in a rectangular body made from ceramic or more commonly plastic, with a row of right-angle leads projecting from the two long edges.

DMA (Direct Memory Access): a method where peripherals share access to RAM and are able to read/write data in the RAM without the core being involved. This improves performance since it allows the core to perform other tasks simultaneously with the peripherals without constant interruption. See also: peripheral.

DMIPS (Dhrystone MIPS): a standard (though not infallible) method for measuring processor performance. Superficially this resembles MIPS but it is calculated by performing a task which is expected to take a certain number of instructions and measuring how long it took. This reveals not only the processor's clock rate but also its processing efficiency. For example, a 1MHz processor may achieve 0.9DMIPS, 1.25DMIPS or some other value. The processor with 1.25DMIPS can on average do more work per clock pulse than the one which only achieves 0.9DMIPS. 1DMIPS is defined as the processing power of an (ancient!) VAX 11/780 running at 1MHz. However,processors can be designed to look good in such benchmarks.

dsPIC: a line of signal controllers from Microchip. These are effectively powerful 16-bit microcontrollers with built-in DSP instructions. See also: DSP, PIC.

DSP (Digital Signal Processor): a specialised variant of a microprocessor with powerful mathematical functions such as fast multiply-accumulate, floating point, SIMD and so on. Used for tasks such as spectrum analysis, filtering and signal analysis.

EEPROM (Electrically Erasable Programmable Read-Only Memory): a type of non-volatile memory which can be erased and re-written. EEPROM usually withstands more re-write cycles than flash memory but is otherwise very similar. See also: flash memory.

Ethernet: a series of network standards which allow data to be transmitted over twisted-pair cable at speeds of 10Mbit, 100Mbit, 1Gbit or 10Gbit.

Flash, flash memory: a type of non-volatile memory where data can be stored for many years. While flash memory can be re-written many times, it has a finite life-span and so is normally used for storing data that changes seldom, eg, program code. Also, the read speed of flash is much higher than the write speed. Flash must be erased before it can be re-written and for this reason it is typically arranged in blocks, which can be erased one at a time or simultaneously. See also: EEPROM.

FPU (Floating Point Unit): the section of a processor which performs mathematical operations on floating point numbers. This makes it much easier and often faster to manipulate fractional numbers, especially those which can have a wide range of values.

GPI/O (General Purpose Input/Output): refers to a processor pin which is capable of being a digital output, which the software can set to either a low or high voltage level, or a digital input, in which case the pin has a high impedance and the software can sense whether the voltage level at that pin is low or high.

I^2C (Inter-Integrated Circuit): a two-wire serial bus consisting of two lines (SDA for data and SCL for clock) plus ground. Uses open-collector signalling to allow up to 1024 slaves to share a single I^2C bus with speeds up to 5MHz.

Instruction: a single command which instructs a microprocessor core to perform a mathematical operation. A series of instructions defines the program code which determines what the processor does. A typical instruction might store a number to a particular location in memory, add two numbers, send a control message to a peripheral and so on.

Instruction set: the variety of different instructions which a CPU core is able to handle. This affects the efficiency of a processor as well as how easy it is to program.

Interrupt: a way for an external event or peripheral to trigger a particular set of instructions in the processor core. When an interrupt is triggered, the instruction flow of the core is interrupted and diverted to a specific set of instructions which are to be triggered on that event (the interrupt handler). When the interrupt handler's task is completed, the processor returns to executing the instruction that it was about to process before the interrupt occurred.

JTAG (Joint Test Action Group): a five-wire daisy-chain serial protocol designed for testing, debugging and programming hardware. Used by many of the more powerful microcontrollers to allow in-circuit debugging and re-programming.

Logic gate: a small circuit which performs a basic digital function. All digital ICs, including microprocessors are built from logic gates. A large processor could contain millions. These days, logic gates are typically designed using Mosfets.

MPU (Memory Protection Unit): digital logic circuitry which interfaces the processor core to memory. Used primarily with multi-tasking operating systems, the MPU is programmed with information regarding which process "owns" which sections of memory by the operating system and then prevents any process from accessing the memory of other processes unless explicitly permitted. Detects and prevents both accidental memory corruption due to software bugs as well as preventing malicious software from interfering with other processes or stealing sensitive data from their memory.

Micro, microcontroller: a small, low-power computer chip. They usually have memory and interface circuitry within the chip. Microcontrollers are built into vehicles, appliances and so on. As the name suggests, are used to control the functions of those devices.

Microprocessor, processor: a computer chip, consisting of an instruction core and support circuitry. The heart of all computers, often referred to as a CPU or Central Processing Unit. See also: microcontroller.

MIPS (millions of instuctions per second): a measure of processor speed, the number of instructions that a processor can execute in a second. This is related to the clock rate; for most modern processors, the clock rate and MIPS figure are identical since they can dispatch one instruction for each core clock pulse. Useful for comparing performance between different chips of a similar design, but not necessarily between different designs due to differing instruction set efficiency. See also: DMIPS.

Multiplexer: a circuit which feeds one signal (analog or digital) to one of several inputs or outputs of another circuit. These can be used to expand the number of effective inputs of an ADC, by connecting different signal sources to the ADC's input at different times. They

can also be used to allow a microcontroller pin to have several different functions, with the software instructing the multiplexer to select which function should be connected to that pin.

Multiplier: the part of a CPU core which can calculate the result of multiplying two numbers. Multiply is a very common operation in some pieces of software and the multiplier performance can determine the overall performance of the software. A 32-bit multiplier is one which can multiply two 32-bit numbers. Faster multipliers take up more space on the chip; a single-cycle multiplier is fastest but also large.

Multiply-accumulate: an instruction which multiplies two numbers and then adds the result to a third number before storing it. A common instruction found in DSPs, sometimes with an option to "saturate" the result (ie, prevent it from rolling over if it gets too large). Used, for example, in Fast Fourier Transform algorithms for spectrum analysis.

NXP (NXP Semiconductors): semiconductor design and manufacture company, previously owned by Philips.

Peripheral: circuitry within a microcontroller which is controlled by, but acts independently of the micro itself. Peripherals perform tasks which are difficult to do with software or that would take up disproportionate amounts of the micro's processing power to perform. They also allow the micro to do several things simultaneously. Examples include ADCs, DACs, PWM outputs (timers) and serial peripherals (SPI, I^2C, etc).

PIC: A line of 8-bit, 16-bit and 32-bit microcontrollers and signal controllers from Microchip. See also: dsPIC.

PICAXE: a range of budget microcontrollers from Revolution Education (UK), based on PICs but pre-programmed with an interpreter using internal EEPROM. Programmed in BASIC language.

PHY (Physical layer): the part of a digital communication device which provides the electrical interface, as opposed to the controller which deals with the protocol itself. This term is typically used in reference to USB or Ethernet interfaces.

PWM (Pulse Width Modulation): a scheme where a fixed-frequency square wave is generated with a variable ratio of on-time to off-time. This affects the average level of the PWM signal and this can be used to vary the power delivered to a load (eg, a heater element or motor).

Quadrature Encoding: a method for signalling rotation using two digital signals. Consists of two square waves, one of which is phase-shifted by 90°. Commonly used with rotary encoders, for motor or wheel rotation feedback or as part of a user interface (eg, a jog wheel).

RAM (Random Access Memory): circuitry where an array of numbers are stored that can easily be changed. RAM is volatile so its contents are lost when power is removed, so it is only used for storing temporary data. RAM is fast to read and write. See also: register.

Register: A type of very fast RAM embedded in a processor. Used for storing numbers which are being worked on. There are usually a limited number of registers (eg, 16); when working on larger sets of numbers, their contents are shuffled into and out of RAM.

RISC (Reduced Instruction Set Count): a type of processor instruction set which is designed to have few instructions, to allow the processor to be smaller, cheaper and run at higher speeds.

ROM (Read Only Memory): memory which can be read but never changed. ROM is used to store things like a processor's type, unique identification number and fixed sets of instructions for performing specialised tasks.

RS-232: a two-wire serial interface with a typical speed of up to 115.2kbps. Works over longer cables than SPI or I^2C.

RTC (Real-Time Clock): a circuit comprising a low-power oscillator (usually crystal locked) and a timer which keeps track of the number of seconds that pass. RTCs often have battery-backup so that even if the processor loses power, it can still keep track of time.

Sample-and-hold: a circuit which freezes an analog voltage at a particular level and holds it there for a certain period. Used in an ADC so that the voltage being converted to a digital format represents the input voltage at a specific point in time, ie, the voltage being converted does not change during the conversion, which could produce an incorrect result.

Serial bus: a method of data communication between two or more ICs that only requires a few wires. Data is sent on a serial bus one bit at a time. Some serial buses are unidirectional and some are bidirectional. The number of wires required varies between one and five or so; with more wires, higher speed communication is possible and data overhead is lower. See also SPI, I^2C, RS-232.

SIMD, Single Instruction Multiple Data: a method to speed up mathematical operations on large amounts of numerical data by processing more than one number at a time. A SIMD instruction typically performs the same operation on two, four or eight numbers at once.

SMD (Surface Mount Device): electronic components which are designed to be mounted on the surface of a PCB rather than with leads passing through holes. SMDs are typically much smaller than through-hole parts and because they don't require holes, can be fitted on both sides of the PCB. SMD microcontrollers come in a large variety of packages, including both leaded and leadless types (eg, BGA or ball grid array).

SPI (Serial Peripheral Interface): a simple, high-speed serial communication bus consisting of three wires (clock and bidirectional data) plus ground and a chip select line for each slave. Data rates in excess of 10Mbit are possible, over short distances.

Timer: an on-chip counter which can be configured to count in a variety of ways. These can be used to keep track of time, generate PWM outputs, generate periodic interrupts and so on. See also: PWM, RTC, Interrupt.

UART (Universal Asynchronous Receiver-Transmitter): a serial peripheral which can be programmed to communicate on a variety of serial buses such as SPI, I^2C, RS-232 and so on.

USB (Universal Serial Bus): a serial bus designed for connecting accessories to a computer. USB carries bidirectional serial data and a 5V power supply over four pins. The original USB had low-speed (1.5Mbps) and full-speed (12Mbps) modes. USB 2 added a hi-speed mode (480Mbps) and USB 3 adds a 5Gbps mode.

USB OTG (USB On-The-Go): a variation on USB which allows a single chip to act as either a host or a device. In other words, you can either plug a device into it (such as USB flash drive) or you can plug it into a computer. This requires a special plug that can take either type of cable. **sc**

WiNRADiO®

By Maurie Findlay, MIEAust

Excalibur

A revolutionary radio receiver

In the legend of King Arthur, "Excalibur" was a sword with magical properties. It is an appropriate name for the latest Software-Defined High Frequency Receiver from WiNRADiO of Melbourne, Australia. Like its namesake, Excalibur is immensely powerful and – dare we say it – almost magical in performance!

Sixty years ago, communication receivers used vacuum tubes and came with precision mechanical dials in big metal boxes.

Thirty years ago, transistors and integrated circuits had replaced the valves and the boxes were smaller.

Today, this new receiver does a great deal more than any of the former and comes in a *very* small sealed metal container – just 156 x 97 x 41mm.

A purchaser receives a professionally presented package which includes the receiver, power supply, cables, user's guide, an SMA/BNC adapter for the antenna socket and a CD-ROM with the application software.

It is assumed that a computer, essential to the operation of the receiver, is already on hand.

The user's guide discusses the requirements for the computer. The one I used is a four year old laptop, Compaq Presario V6000 running Windows XP, and is about the minimum standard suitable for the job. Windows 7 or Vista would be the operating system in more modern computers. The hard disk must have at least 20MB of free space to hold the information from the CD-ROM.

After connecting the receiver, loading the CD-ROM and attaching a random (short) length of wire to the antenna socket, I followed the user's guide and within five minutes was hearing my local station on 702kHz, through the speakers in the computer. Another five minutes and I was able,

I came across abbreviations such as DDC, DDS and SDR. For the uninitiated (like me!) these stand for digital down-conversion, digital direct sampling and software-defined receiver.

While these are explained early in the guide, it would have been easier to study if these abbreviations had been spelled out at the beginning of each section where they occur. A detailed index at the rear would have made the job of finding information easier. There is a 3-page table of contents at the front.

The initial screen is shown above. It is pin sharp and full of detail. The panel at the top left indicates the frequency to which the receiver is tuned, in this case 1278kHz; towards the high frequency end of the standard medium wave band. To the right of the frequency indication is a knob which can be operated by the computer (mouse) to change the one by one, to tune in all my local stations on the default AM setting of the receiver.

Yet another five minutes with the guide and I was able to receive the local stations in the USB (upper sideband) and LSB (lower sideband) modes. That is, with the receiver-generated carrier substituted for the incoming carrier.

It is that easy to get started.

The 107-page User's Guide is packed with well written information. Most owners, new to software-defined high frequency receivers, will take several weeks to fully appreciate the facilities offered by Excalibur.

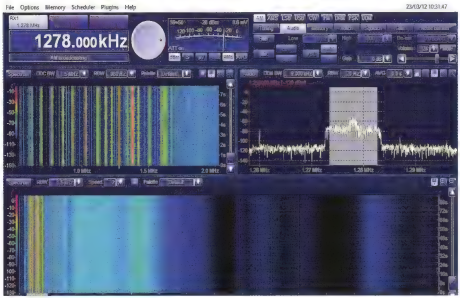
In addition to the manual, there a great deal of helpful information on www.winradio.com

DDC? DDS? SDR?

Although I have a background in the design and manufacture of commercial radio equipment ranging from the valve days to high performance types using semiconductors, I am one of those new to this technology.

For the first time, in the guide,

End-on view of the WiNRADiO Excalibur WR-G31DDC HF receiver, shown here close to life-size. Controls on the box are non-existent; everything is done by the attached computer.



G31DDC receiving a broadcast station on 1278kHz with the spectrum displayed in the "Waterfall" mode. It makes a colourful change!

frequency. Alternatively, the frequency can be entered from the keyboard. The receiver covers the range from 9kHz to just below 50MHz.

To the right of the knob is a meter indicating the strength of the incoming carrier: in this case -28dBm. The buttons below the meter allow the strength to be indicated in dBm, µV or "S" units, the last being the usual means of reporting signal strength on the amateur bands.

Buttons at the top right, accessed by the mouse, allow the receiver to be set for nine different modes of reception: AM, AMS, LSB, USB, CW, FMN, FSK, UDM (user-defined mode) and DRM mode (optional). Below them are a further eight buttons which access other functions including volume, squelch and noise blanker.

Spectrum analyser

Across the bottom of the screen is a spectrum analyser display, in this case set to cover 0 to 30MHz. Strong signals in the AM broadcast band appear to the left. Above that is the spectrum, expanded to cover the band from 0.5 to 2MHz. Individual carriers of the local stations can be picked out very clearly.

A third display, to the centre right, covers only 50kHz and allows the audio spectrum of the incoming signal to be seen. The shaded area indicates the receiver bandwidth and can be changed by clicking the "BW presets" button above that display.

So in addition to being a high performance communication receiver, Excalibur is a very useful spectrum analyser.

It is designed to match an antenna with a source impedance of 50Ω and the short length of wire I used initially is not very efficient. The receiver can be used for general shortwave listening with a long length of wire, attached to the antenna terminal and preferably outside the building but even this does not give the best results.

WiNRADiO are able to supply an aerial transformer which gives better results with random lengths of wire. The transformer is connected to the receiver via coaxial cable and can be placed well away from any local sources of interference. A ground point can be connected to the transformer.

Commercial users and amateur radio people using the receiver will normally have tuned 50Ω antennas which can be directly connected to the antenna terminal. In this case, of course, it will only work efficiently for the particular band and the spectrum analyser will clearly indicate the resonance of the antenna.

Because of the spectrum analyser presentation and many other features, amateur (and perhaps even professional) radio operators may use the WiNRADiO Excalibur to replace the receiver section of an older transceiver. Great care must be taken with the switching arrangement to ensure that radio frequency energy from the transmitter does not reach the receiver antenna terminal.

A simple changeover relay, operated by the press-to-talk switch, is not satisfactory because the proximity of the active arm of the relay and the receiver contact will allow appreciable power to be transferred. A specialised antenna changeover circuit, designed for the task, should be used.

Audio quality, particularly the lower end of the range, is limited by the small speakers built into the computer. For many users this will be all that is required. However all computers these days have an audio output jack which can be used to feed a better quality audio system.

Modes

Modes of reception for the receiver include the conventional AM (amplitude modulation), LSB (lower sideband), USB (upper sideband, not to be confused with the universal serial bus USB) and CW (continuous wave - for Morse code). In addition, AM can be received as AMS (amplitude modulation - synchronous demodulation) in which case the received carrier is replaced by a locally generated carrier. One or both sidebands can be selected. This results in a reduction of the distortion caused by selective fading, particularly with weak signals on the shortwave broadcast bands.

Narrow band FM (frequency modulation) signals can also be received. Digital, frequency shift keying and user-definable modes are also discussed in the User's Guide.

Selectivity is variable in fine increments from a bandwidth of 50kHz to 10Hz. The former is suitable for wideband AM and the latter for CW under difficult conditions. The standard mode for voice communications on the high frequency bands is SSB and a bandwidth of around 3kHz can be selected for best signal-to-noise ratio.

Upper sideband is normal, although radio amateurs use lower sideband on frequencies below 9MHz. There is no special technical advantage in using LSB; it goes back to the early history of the development of sideband on the amateur bands.

Tuning accuracy is given as 0.5 parts/million @ 25°C but the sample provided for review was better than that.

Furthermore, the User's Guide shows a method of adjusting the internal crystal oscillator against an external standard. This is of immense value when using the WiNRADiO Excalibur

a perfect circle.

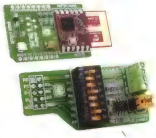
Experience the powerful **mikroC™**, **mikroBasic™** and **mikroPascal™** compilers for **ARM® Cortex™-M3** and **M4** devices. Over 500 library functions with examples and a comprehensive help file will help you get your project done quickly.

Easily create GLCD or TFT user interfaces using **Visual TFT™** and **Visual GLCD™ software**. Just focus on design and code will be created for you automatically.

mikroProg™ for Stellaris® and **mikroProg™ for STM32™** are fast programmers and hardware debuggers. Each of them supports the entire family range of both **Cortex™-M3** and **Cortex™ M4** microcontrollers from their respective vendors. Both mikroProgs are supported with MikroElektronika **ARM® compilers.**

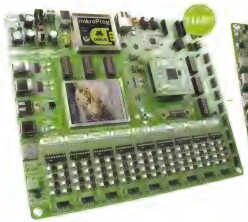
COMPLETE ARM®

DEVELOPMENT SOLUTION for Stellaris® and STM32®



Over 200 IDC10 and mikroBUS™ compatible Click™ additional boards are here to meet your development ideas.

mikromedia™ boards for **Stellaris®** and **STM32®** are real Swiss army knives for multimedia developers. They are packed with lots of multimedia peripherals.



EasyMx PRO™ v7 for Stellaris® is a full-featured development board for **Stellaris® ARM® Cortex™-M3** and **Cortex™-M4** microcontrollers. It contains many on-board modules including multimedia, Ethernet, USB, CAN and other. Board is delivered with MCU socket containing LM3S9B95.

We supported all **STM32®** microcontrollers with **EasyMx PRO™ v7 for STM32®** development board. It features mikroProg™ hardware debugger and contains many on-board modules including multimedia, Ethernet, USB, CAN, two mikroBUS™ sockets and many other.

MikroElektronika
DEVELOPMENT TOOLS | COMPILERS | BOOKS

GET IT NOW
www.mikroe.com

WiNRADiO WR-G31DDC 'EXCALIBUR' SPECIFICATIONS

Receiver type:	Direct-sampling, digitally down-converting software-defined receiver
Frequency range:	9kHz to 49.995MHz
Tuning resolution:	1Hz
Modes:	AM, AMS, LSB, USB, CW, FMN, FSK, UDM (user-defined mode) DRM mode (optional)
Image rejection:	90dB typical
IP3 (intercept point 3rd order):	+31dBm typical
Attenuator:	0 - 21dB, adjustable in 3dB steps
SFDR (spurious free dynamic range):	107dB typical
Noise figure:	14dB
MDS (minimum discernible signal):	-130dBm @ 10MHz, 500Hz BW
Phase noise:	-145dBc/Hz @ 10kHz
RSSI (received signal strength indication) accuracy:	2dB typical
RSSI sensitivity:	-140dBm
Processing and recording bandwidth (DDC bandwidth):	20kHz - 2MHz (selectable in 21 steps)
Demodulation bandwidth (selectivity):	10Hz - 62.5kHz (continuously variable in 1Hz steps)
Spectrum analysers:	Input spectrum/waterfall, 30MHz or 50MHz wide, 1.5kHz resolution bandwidth
	DDC spectrum/waterfall, max 2MHz wide, 1Hz resolution bandwidth
	Channel spectrum, max 62.5kHz wide, 1Hz resolution bandwidth
	Demodulated audio, 16kHz wide, 1Hz resolution bandwidth
ADC (analog/digital converter):	16 bit, 100 MSPS (mega-samples per second)
Sensitivity (typical @ 10MHz):	AM -101dBm (2.00 µV) @ 10dB S+N/N, 30% modulation
	SSB -116dBm (0.35 µV) @ 10dB S+N/N, 2.1kHz BW
	CW -123dBm (0.16 µV) @ 10dB S+N/N, 500Hz BW
	FM -112dBm (0.56 µV) @ 12dB SINAD, 3kHz deviation, 12kHz BW,
	audio filter 300-3000Hz, de-emphasis -6dB/octave
Note: Below 200kHz, the sensitivity gradually drops.	
Typical figures (CW, 500Hz BW, 10dB S+N/N) are as follows:	200kHz -123dBm; 100kHz -116dBm; 50kHz -112dBm; 25kHz -97dBm; 10kHz -81dBm
Tuning accuracy:	0.5 ppm @ 25 °C
Tuning stability:	2.5 ppm (0 to 50 °C)
MW filter:	Cut-off frequency 1.8MHz @ -3dB; Attenuation -60dB min @ 0.5MHz
Antenna input:	50Ω (SMA connector; SMA to BNC converter supplied)
Output:	24-bit digitised I&Q signal over USB interface
Interface:	USB 2.0 Hi-speed
Dimensions:	156 x 97 x 41mm
Weight:	430g
Power supply (operating):	11-13V DC @ 500mA (typical, operating); 45mA (typical, power save)
Operating temperature:	0 to 50 °C

as a communication receiver because the transmissions are frequently too short to give time for retuning. With this accuracy, you can be sure of clear audio even with SSB at the higher frequencies.

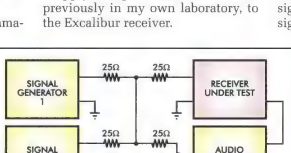
A feature of the receiver is the ability to receive three signals at the one time provided that they fall within the range of the DDC (digital down converter) analyser which has a maximum bandwidth of 2MHz.

This could be of value on the amateur bands; however most of the allocated channels for the marine, flying doctor and VKS-737 high frequency networks, that you may wish to monitor at the same time, are separated by more than 2MHz.

Sensitivity & blocking

There are two features of communication receivers which separate "the men from the boys". First is sensitivity – the ability to receive very weak signals; the other is blocking performance – the ability to receive those weak signals in the presence of strong signals on adjacent frequencies. This is particularly important on the crowded amateur bands.

There are a number of accepted tests for sensitivity and blocking. I decided to apply a simple test, that I have used previously in my own laboratory, to the Excalibur receiver.



The test setup I use for communications receivers. It revealed an outstanding result.

It was tuned to 10,000.0kHz SSB (upper sideband), with a bandwidth of 3kHz, and a signal at 10.001.5kHz applied to the antenna terminal. The signal generator has a source impedance of 50Ω and the receiver a nominal input impedance of 50Ω.

The attenuator of the generator indicates the signal level at the receiver. (The audio output of the receiver is a tone at 1,500Hz.) The output of the signal generator was reduced until the signal plus noise to noise ratio of the output was 10dB. The signal level at the antenna terminal was -112dBm (0.5 µV).

Now for the hard one. A resistive network was arranged so that two signal generators could be connected to the receiver, both generators being correctly terminated and the source resistance, as seen by the receiver, still 50Ω. The level of the first generator was increased so that the S+N/N was still 10dB.

The second signal generator, tuned to 10,020Hz, was fed into the network and the level adjusted until the S+N/N changed by 3dB. The level at the receiver terminal when this happened was -7dBm (0.1V). That is, 105dB above the wanted signal.

All these tests were done without the input attenuator of the Excalibur in operation.

A figure of 90dB was considered the norm for high-standard communication receivers when I was involved in their design and manufacture – so at 105dB this receiver is very good indeed; exceptional, in fact.

However, it could be even better: discussions with WiNRADiO engineers suggest that shortcomings of the signal generators I used may have influenced the test so that the real blocking figure may well be greater than 105dB.

Interference? Notch it out!

The Excalibur has another trick up its sleeve, for dealing with high level adjacent channel blocking signals, in the form of a notch filter. This can be brought into operating by clicking the Notch button when the frequency and width of the notch can be adjusted. (The interfering signal can be seen on the analyser display.)

Space in the User's Guide is devoted to the elimination of interference, particularly that from the computer, which is an essential part of the receiving setup. When I initially operated the receiver, with a short length of wire close to the computer for an antenna, the interference was obvious.

However, when an outside length of wire or a tuned antenna was used, computer noise was swamped by the incoming signals (as you would expect). Obviously, the noise generated by various computers will be different but with my "typical" PC, performance was outstanding.

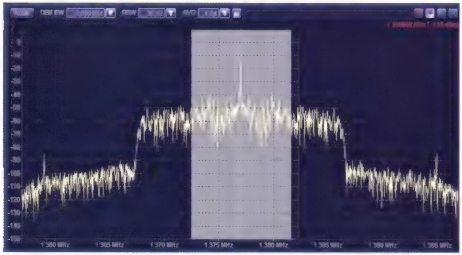
It is not true to suggest that newer PCs may be better in the noise department than older models – some recent PCs (escpecially plastic-cased laptops and notebooks) have been woeful in this regard compared to their forebears. But I am confident in suggesting that with rare exceptions (and a proper antenna) computer noise should not be an issue.

Software control of the receiver makes possible a large number of useful adjustments and displays which would be quite impractical with the conventional design. One of the most important is the ability to vary the bandwidth in small increments.

A conventional superhet may have a crystal filter with a bandwidth of 6kHz for AM and another with 3kHz bandwidth for single sideband but there will be times when different selectivity will allow better reception.

The Excalibur has a conventional spectrum analyser, which plots frequency against amplitude (ie, frequency domain), while frequency may be plotted on a linear scale in the horizontal and amplitude on a vertical logarithmic scale. It also offers the alternative of a "waterfall" display, which some users may prefer.

Other facilities offered by the Excalibur include the ability to record various settings and also received programs.



The spectrum analyser displaying the demodulated signal from a broadcast station. The shaded area indicates the sidebands, each side of the carrier (the peak in the centre), which are passed on to the audio amplifier.

Would you like to work for this innovative company?

WiNRADiO®

is seeking bright, enthusiastic Electronics and RF Technicians/Engineers for R&D work, prototyping, testing and production.

Interested? Then send us your application with your professional background addressed to:

careers@winradio.com

WiNRADiO Communications
15 Stamford Road
Oakleigh, Vic 3166
Ph (03) 9568 2568, ext 0204

Conclusion

The WiNRADiO G31DDC Excalibur offers a tremendously powerful performance at a cost less than that of a conventional communications-standard superhet receiver.

This is the way of the future.

It is sold direct from WiNRADiO's online store in Australia or through a number of specialist communications distributors overseas.

For readers who don't have Windows-based PCs, WiNRADiO also have available MacRadio and LinRadio (Linux) versions.

Acknowledgement:

We gratefully appreciate the assistance of Helmut Riexinger of WiNRADiO Communications in the preparation of this review. SC

Where from, how much:

The WiNRADiO Excalibur WR-G31DDC receiver is made in Australia by WiNRADiO Communications, 15 Stamford Road, Oakleigh, Vic, 3175. Phone: (03) 9568 2568 Web: www.winradio.com

Recommended retail price is $995.00 +GST

Readers in Australia should contact WiNRADiO direct via their website or phone; readers in other countries can contact their local distributors (details on the WiNRADiO website)

Crazy Cricket . . . or Freaky Frog!

Love the sound of crickets and frogs (and who doesn't)? Maybe you will revise your judgement after exposure to Crazy or Freaky – the (very) pesky cricket and equally annoying grenouille.

Designed to imitate the chirping noise of a cricket or the gentle croaking of a frog, Crazy/Freaky loves to sing in the dark and happily chirps/croaks away, much to the annoyance of others.

When disturbed by light, he immediately shuts up, remaining stealthy and silent. He keeps his location secret until conditions become favourable when he begins to chirp again.

To make life simple, we'll just refer to Crazy – but remember every other time you turn him on he becomes Freaky.

He's sneaky!

Crazy does not immediately begin to chirp when darkness falls. He may wait a second or two or he may delay his singing for up to 40s. By this time you may think he has (thankfully) moved away. But start to chirp (he eventually will) and you will then know that Crazy is a very happy little insect. Call him pesky, call him annoying but we just call him Crazy.

You may think that this behaviour is just like any ordinary cricket or frog, but naturally Crazy is different. Ordinary crickets make sounds to establish their territory or attract a mate. And their chirping sounds are produced by rubbing a coarse section of one wing against a scraper located on the other wing. This process is called stridulation.

Crazy does not stridulate! Nor does he need to attract a mate (well, not that we've noticed). However, he does claim his territory. This territorial claim remains until he is discovered whereupon his final fate remains uncertain.

There may be search-and-destroy missions to locate Crazy but he is very elusive. One thing against him is that his eyes glint in the dark and this may reveal his position. More than likely though, his eyes will terrify the unwary.

by John (Chirpy) Clarke

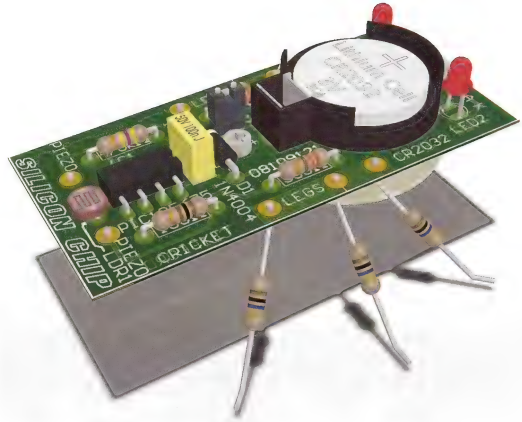
While ordinary crickets are made from biological materials, Crazy is an all-electronic insect manufactured from numerous elements including silicon, iron, copper, carbon and silica. He also incorporates man-made plastics in his construction that are rather difficult to pronounce for a cricket.

When attempting to pronounce his material make-up he is sometimes heard expressing just the word "chip". It's derived from the longer expression "silicon chip".

Whether this expression sets Crazy apart as being more highly evolved than his biological counterparts is unknown.

As Crazy says, he does include a silicon "chip" in his make up. In this design the chip is a PIC microcontroller and that vastly simplifies his circuitry.

Just as crickets evolve in nature, this makes this new design an evolutionary improvement over the previous but ever popular "Clifford the Cricket" from December 1994. In that circuit a



Easy to build but hard to ignore – Crazy Cricket, shown here in 3D, chirps away in the dark and flashes his LED eyes . . . until you turn the lights on. Then he shuts up until it gets dark again. We've shown Crazy here with resistor "legs" coming from the underside of the PCB – while this is perfectly acceptable, they could just as easily come from the top side and bent over the edge of the board. Or indeed, they could have been made from tinned copper wire. The PIC micro is also programmed with Crazy's alter-ego, Freaky Frog. Each is selected in an alternate fashion on each supply power-up.

CMOS hex inverter was used instead.

Further improvements over the previous 1994 design include reduced component count, smaller and more compact construction and significantly lower current drain.

This low current allows the use of a lithium 3V cell. That's in contrast to the 1994 version that used a rather large 9V battery. That battery acted more like a convict's ball and chain, with the weight often restricting Clifford from his annual winter migration northward to a warmer climate.

The 1994 chirping sound was rather limited and comprised a 2kHz tone modulated at 160Hz and at 25Hz. This didn't simulate a real cricket.

He's *real* (almost)!

For this latest version, we wanted Crazy to sound more realistic, so the sounds made by Crazy are based upon a real cricket's chirping. Typically, a cricket produces three close-together chirps each separated by silence – then an even longer silence, before repeating these triplet chirps.

Fig.1 shows a typical cricket chirping waveform. Each individual chirp comprises a tone of about 4kHz that lasts for around 50ms. The spacing between each chirp is also around 50ms. A much wider spacing is between each triplet at around 250ms. As expected, without arms (he has six legs!) a cricket does not have an accurate timepiece to set these periods precisely and so these periods do vary a little.

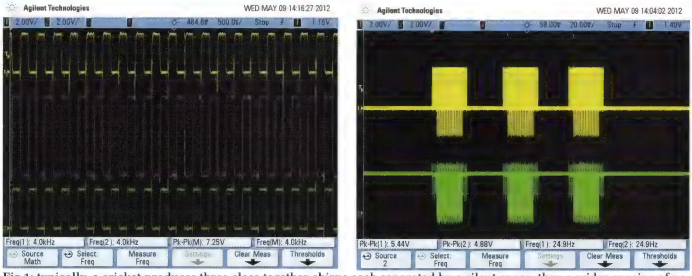


Fig.1: typically, a cricket produces three close together chirps each separated by a silent space, then a wider spacing of no sound before repeating these triplet chirps. The scope grab on the left is a close-up of the drive waveform fed to the piezo sounder. Channels 1&2 (yellow and green) are at either end of the piezo while the mauve trace shows the difference – that is, the full 6V across the piezo while that on the right shows one burst of cricket sound.

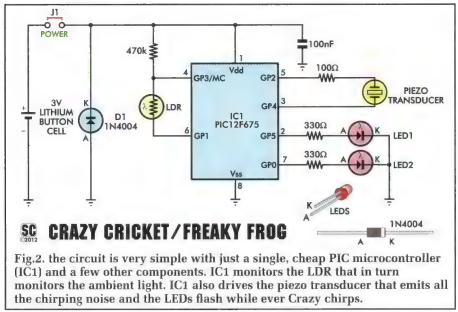


Fig.2. the circuit is very simple with just a single, cheap PIC microcontroller (IC1) and a few other components. IC1 monitors the LDR that in turn monitors the ambient light. IC1 also drives the piezo transducer that emits all the chirping noise and the LEDs flash while ever Crazy chirps.

The tone of the chirp, however, does not appear to vary by any noticeable degree.

Crazy simulates the cricket chirp by producing the three 4kHz chirps separated by the longer spacing. When reproducing this waveform, we found that a 50ms chirp with 50ms gap for each chirp triplet tended to sound more like an umpires whistle (NOT a cricket umpire . . .) than a cricket!

Clearly there is a difference between a real cricket's stridulation and a generated waveform driving a piezo transducer. In order to sound more realistic, the simulated chirps were reduced to 20ms wide with 20ms gaps between them. The standard cricket 250ms spacing between the three chirps, however, is incorporated into Crazy's voice.

Variations

As mentioned, a cricket does not produce precise periods in its chirping. To simulate this variation, Crazy has his chirping periods varying randomly over a limited range. The variations are weighted so that the 20ms and 250ms periods are more common compared to rarer wider and narrower periods. The variations in the periods provide a more natural cadence to Crazy's chirping. The variations prevent the simulated cricket sound from being too regular, relentless and artificial.

Physical appearance

Crazy is made up using a small PCB (printed circuit board) with the components mounted onto this. Most parts are mounted on the top of the PCB including the cell holder and eyes, made from 3mm diameter red LEDs. The piezo transducer that produces the cricket sound is slung beneath the PCB. Legs; six in all, are fashioned from spare resistors – or you could use tinned copper wire.

The circuit

As shown in Fig.2, Crazy's circuitry is very simple, comprising a PIC microcontroller, IC1 and just a few associated components.

It's powered by a 3V lithium cell, switched via a jumper link JP1. The jumper is removed when Crazy is not used to save any power draw from the cell. The circuit does not draw much current anyway – typically only 3µA when Crazy is dormant in lighted conditions. Current drain while chirping is 1mA.

Diode D1 is included as a safety measure to prevent damage to IC1 should the cell be connected incorrectly somehow. This could happen if the cell holder is installed the wrong way round.

If the polarity is wrong, diode D1 will shunt the reverse current. If the cell holder is installed correctly, then because of the way the CR2032 cell is made, there is no way that it can be inserted back-to-front. At least that is true for the particular cell holder we used.

IC1's power supply is bypassed with a 100nF capacitor and IC1 runs using its internal 4MHz oscillator. When Crazy is dormant and awaiting darkness, this oscillator is shut down (put into sleep mode) to save power.

A low frequency watchdog timer is set running to waken IC1 approximately each half second. During the woken period, IC1 checks the ambient light level from the light dependent resistor (LDR1).

Normally, IC1's GP1 output is set high (3V) and so there is no current flow through the 470kΩ resistor and the LDR. Again, this is done to minimise current drawn from the 3V cell. When IC1 is awake, it sets output GP1 low (0V) and the LDR forms a voltage divider in conjunction with the 470kΩ resistor across the 3V supply. The voltage across LDR1 is monitored at input GP3.

In darkness, the LDR resistance is high (above 1MΩ) so the voltage at input GP3 is more than 2V due to the voltage divider action of the LDR and the 470kΩ resistor. This voltage is detected as a high level by IC1. The high level tells IC1 that Crazy is in the dark. With bright light, the LDR will drop in resistance, down to around 10kΩ, which produces a low level at input GP3. IC1 recognises this as Crazy being located in a lighted area.

Output GP1 is only held low for a short duration, sufficient for ambient light readings from the LDR. GP1 then returns high to save power.

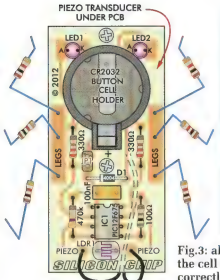
Software solutions

Note that the GP3 input in many projects is often configured as the MCLR input (master clear), which allows the microcontroller to have an external power on reset. However, for our circuit we need to use this as a general purpose input for monitoring the LDR.

When MCLR is set up as an input, the MCLR operation is switched to an internal connection within the microcontroller so the master clear power-on-reset function is not lost. One disadvantage of using this as a general purpose input is that it is not a Schmitt trigger input.

The lack of a Schmitt trigger input at GP3 can mean that, at a particular ambient light level, the input to GP3 could be read as either a high or low input level by IC1's software. At this threshold, Crazy could produce strange sets of chirping as IC1's software switches on and off the chirping, undecided as to the ambient light level.

We solve this by making sure that once Crazy is switched on (in darkness), he is not switched off until the



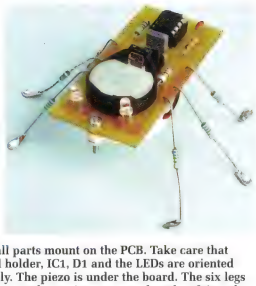


Fig.3: all parts mount on the PCB. Take care that the cell holder, IC1, D1 and the LEDs are oriented correctly. The piezo is under the board. The six legs can be any value resistor or even lengths of tinned copper wire. Note the turned-back and soldered safety "feet" in the photo above.

ambient light reaches a significantly higher level. This difference in level is called hysteresis.

Hysteresis is implemented by pulsing the GP1 output momentarily high when checking for a high ambient light level. High ambient light means that the LDR resistance is low, so the GP3 input is a low voltage. The momentary high pulse level effectively raises the GP3 voltage slightly since this pulse is filtered due to the internal capacitance at the GP3 input of 50pF or less. The raised voltage means that the LDR is required to have a lower resistance (ie have more light shining on it) to bring the GP3 voltage low enough for a low input reading by IC1.

The second disadvantage of using the MCLR pin as a general purpose input is that there can be a problem when programming the microcontroller. This problem occurs when the internal oscillator is also used to run the microcontroller (which we do). We solve this problem in the software and the solution is discussed later under the 'programming' subheading.

Output drivers

Outputs GP0, GP2, GP4 and GP5 on IC1 are used to drive the LEDs and piezo transducer.

The piezo transducer is driven via both the GP2 and GP4 outputs. When output GP2 is high, GP4 output is low and when output GP2 is taken low, output GP4 is taken high. This provides a full 3V peak square wave drive to the transducer.

A 100Ω resistor limits peak current at the switching of the outputs.

LED1 and LED2 are independently driven via outputs GP5 and GP0 respectively, via 330Ω resistors. These LEDs are driven for short bursts while Crazy is producing a tone. Only one LED is driven at one time to limit the peak current drawn from the battery, to extend its life.

Construction

Crazy is constructed on a PCB coded 08109121, measuring 30 x 65mm. He is presented as a bare PCB with wire legs upon which to stand. Check the PCB for any problems such as undrilled holes or breaks in the tracks. Faults are unlikely since PCBs these days are generally of excellent quality, particularly if you are using a board supplied by SILICON CHIP or any of the kit suppliers.

Fig.3 shows the PCB overlay. Begin construction by installing the resistors, using a multimeter to check the value of each before inserting into the PCB. You might note that for this project we have also shown the individual resistor colours on the PCB overlay.

As mentioned earlier, the legs can be either spare resistors or lengths of tinned copper wire. We prefer resistors but please yourself! Of course, the resistor values for the legs doesn't matter to anyone except, perhaps, Crazy (would you like it if you had six different legs?).

Diode D1 can now be installed, taking care to orient correctly. The 100nF capacitor can be soldered in next and it can be positioned either way round.

Then solder in the 2-way pin header along with the cell holder – make sure the plus terminal is oriented toward diode D1 on the PCB.

LED1 and LED2 are mounted raised off the PCB by about 10mm. The leads can be bent so that each LED sits horizontally and faces outward toward their corner of the PCB. Make sure the longer lead of each LED (the anode) is inserted in the "A" position on the PCB. The LDR is mounted about 5mm above the PCB surface and sits horizontally.

Whether you use resistors or wire for the legs, they should be cut to about 35mm long, with a small loop formed on the outer ends so that the wire end is not sharp. These loops can be filled with solder. Bend the legs so that Crazy can stand upright.

The piezo transducer is mounted on the underside of the PCB supported on TO-220 insulating bushes used as spacers and secured with short M2 screws and nuts. The wires can be soldered to the underside of the PCB (the positions are marked 'piezo') or brought around to the top of the PCB and soldered in the normal way. Heatshrink tubing over the wires to the PCB will help prevent the wires from breaking off.

While the piezo will probably come with red and black wires, indicating that it is polarised, in this case it

Freaky Frog

Crazy has an alter-ego (or should that be alternate ego?), Freaky Frog, who produces frog "knee-deep" sounds instead of cricket sounds. If you prefer frogs to crickets or tire of Crazy and want a change, then replace all references in this article to Crazy with Freaky.

Freaky has a different cadence to Crazy and produces a set of 10 chirps 10ms long with 2ms gaps. This is followed by a 30ms gap and then another set of 3-chirps 10ms long with 2ms gaps. The 10/3 sets are separated by between 200 and 1200ms that varies irregularly. The frequency of the chirps is set at around 2kHz.

Both Crazy and Freaky are in the PIC program – each time you turn it on, the alternate program runs.

Parts list – Crazy Cricket/ Freaky Frog

1 PCB coded 08109121, 30 x 65mm (available from SILICON CHIP for $10 plus p&p – see pp 96-97)
1 20mm button cell holder (Jaycar PH-9238, Altronics S 5056)
1 CR2032 Lithium cell (3V)
1 30mm diameter piezo transducer (Jaycar AB-2440, Altronics S 6140)
1 LDR 10kΩ light dependent resistor (Altronics Z 1621; Jaycar RD-3480) (LDR1)
2 TO-220 insulating bushes
1 DIL8 socket
2 M2 x 8mm screws with nuts
1 2-way pin header (2.54mm pin spacing) with jumper shunt (J1)
1 25mm length of 2mm heatshrink tubing

Semiconductors

1 PIC12F675-I/P programmed with 0810612A.hex (IC1)
1 1N4004 diode (D1)
2 3mm high brightness red LEDs (LED1,LED2)

Capacitors

1 100nF 63V or 100V MKT polyester

Resistors (0.25W, 1%)

1 470kΩ 2 330Ω 1 100Ω
6 resistors for legs *or*
250mm 0.7mm tinned copper wire

doesn't matter – either wire can be soldered to either "piezo" position.

Note that if you intend to program the PIC yourself, hex file 0810612A.hex can be downloaded from the SILICON CHIP website. Also see the section under programming for details about how to do this.

Solder in either the IC or the IC socket, making sure it is oriented correctly. If using a socket, place the IC in it now – watch out that you don't bend the pins! Now install the CR2032 cell in its holder and place the jumper link onto the 2-way header (JP1). If all is well, the LEDs will momentarily flash after about 3s to acknowledge power has been connected.

An acknowledgement by a brief flashing of the LEDs also occurs when a low light level is detected. Low light can be simulated by covering over the LDR. Crazy will then begin chirping after a delay of about 10 seconds, providing the low light level remains.

From then on, Crazy will randomly vary his waiting period before chirping begins at the onset of darkness.

Modifications

Crazy has a loud chirp so that he will be heard effectively even if hidden in a dark cupboard. If you require less volume, then change the 100Ω resistor in series with the piezo transducer to a higher value such as 4.7kΩ or 10kΩ for a nominal reduction in perceived volume by about 50%. Higher values again will give even less volume.

The light level threshold can be altered by changing the 470kΩ resistor in series with the LDR. A lower resistance value (say 100kΩ) will have Crazy chirping at a higher ambient light level. By contrast, increasing the resistance value will mean that Crazy will need a darker light level before he begins chirping.

Programming

If you are programming the microcontroller yourself, you may be presented with a warning by the programmer stating that programming is not supported when both the MCLR is set as a general purpose input and with the internal oscillator set.

However, you will be able to program the microcontroller successfully, ignoring the warning. That's because any problems associated with this configuration is already solved by a software solution. Read on if you want more details.

As mentioned, we set MCLR as a general purpose input and utilise the internal oscillator within IC1. This can present problems for a programmer during the process of verifying the software code after programming.

The problem lies in the fact that as soon as the microcontroller is programmed, it will begin executing its program. A typical program initially sets up the microcontroller with the general purpose (GP) lines set as inputs or outputs (I/O). This conflicts with the programmer needing to use the clock and data programming I/O lines for program verification.

This problem does not happen if the MCLR pin is set as the external MCLR input because the programmer then has control over the microcontroller, stopping it from executing the programmed code.

Note also that in order to run the code, the microcontroller has to have the internal oscillator configured instead of an external crystal, RC or external clock oscillator.

The programming problem is solved in the software provided by including a three second delay at the start of the program. This delay is before the I/O lines are set as inputs or outputs. The I/O lines therefore remain as high impedance inputs while the programmer verifies the internally programmed code using the clock and data programming lines.

A warning from the programmer will still be issued but the microcontroller can be programmed successfully and correctly verified by the programmer.

Note that the PIC12F675 also needs special programming due to the fact that it has an oscillator calibration value (oscal) that is held within the PICs memory. This calibration value is individually programmed into each PIC by the manufacturer and provides a value that allows setting of the PIC to run at an accurate 4MHz rate using the internal oscillator.

This value must be read before erasure and programming so that it can be included with the rest of the code during programming. If this procedure is not done, then the oscillator frequency could be off-frequency. That will have an effect on Crazy's chirp.

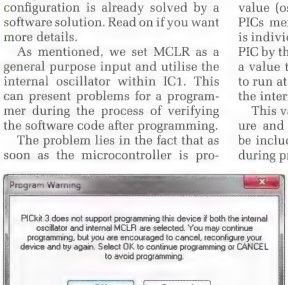


Fig.4: if you see this warning (or similar) when attempting to program the PIC, simply ignore it (ie, just press OK).

Most PIC programmers will automatically cater for this oscal value – but it is worthwhile checking if your programmer correctly handles this, especially if you have difficulties.

Finally, be aware that the PIC12F675 requires a 5V supply for programming, even though it happily runs at 3V in the circuit. SC

OATLEY ELECTRONICS

www.oatleyelectronics.com

WE ARE MOVING

There may be some delays to deliveries. Please be patient and allow a little extra time for delivery of your order during June.

K318 10W WEATHER-PROOF FLOODLIGHT KIT

This kit comes complete with 1 X 10W LED, 1 X 10W LED driver kit, 1 X Weatherproof, diecast aluminium housing

ONLY
$29

As reviewed in Silicon Chip Magazine.

10W LED FLOOD LIGHT KIT PACKAGE

2 lamps wired in series with our 24V PSU.
2 X LED FLOODLIGHT KITS + 1 X 24V POWER SUPPLY [K318P] $60

FLEXIBLE 12VDC LED STRIP WATERPROOF (IP65)

3W per 500mm

These LED strips are designed to operate from nominal 12VDC regardless of length Ideal for use in cars, boats. caravans and sheds etc. With a self adhesive backing and a clear PVC front coating. These strips can be easily joined or connected by wire to form greater lengths or can be cut into multiples of 100mm. [LS500R] $50 PER 5M roll or [LS500] $7 per 500mm

BARGAIN LOW VOLTAGE LIGHTING PACKAGE

This package contains 5 12V-24V, 4Watt LED "PURE WHITE" MR16 replacement lamps + a 240VAC - 24V / 1A switch mode power supply that can power all 5 lamps.

$44

[K2[illegible]P]

K320 3W LED AND DRIVER

$10 for 3 kits

The LED colour is called "Pure white", 240Lum.- 3 X 80Lum. The Driver has a on-board rectifier so polarity is not important.

The LED circuit board should be mounted on a metal surface as it requires additional heat-sinking (silicon Heatsink paste inc.).

ULTRA-SONIC PARKING RADAR

This kit comes with all parts required and includes cables and connectors. The driver's display shows distance (max 2.5M) via a 7 segment display, left & right LED bar-graphs and audible alarm. The distance displayed is surprisingly accurate and has a 100mm resolution. Paint and moisture don't seem to bother the sensors and the radar will work with 1, 2, 3 or 4 sensors. [K304] $35

20W LED + DRIVER SPECIAL

This kit comes with a...
20W, 2000lm "PURE WHITE" LED plus a 12Vdriver kit plus a small fan. The LED will need to be mounted on a small plate or heatsink.

[20WP]
$30

COLOUR HD DVR IDEAL FOR CAR.

2.5" TFT Colour monitor. LED's for night time vision. 120deg.viewing angle. Rotating screen, 270 deg. Res. 1280x960, 720x 480 or 640x480. MICRO SD card up to 32GB. Records automatic-ally on power up. Time & Date display on video. Cycled recording. Car charger:12 or 24 Interface: USB 2.0. Li-ion battery. Video Form at: AVI. Still image format: JPEG Comes with...8GB MICRO SD card, Car DVR, 1 x Suction Mount, 1 x USB Cable, 1 x Car Charger, 1 x Manual, 1 x Battery. [HDDVR]

$69
With 8GB MICRO SD CARD

SPECIALS

62W SOLAR PANELS + Reg.$150.00

High quality Waterproof, Aluminium framed 12V/62W Solar Panels. These employ 40 cells instead of the usual 36. This results in a higher output at low light levels, and at higher temperatures. 678X870X35mm, Voc:22V, Isc:3.76A, Vmp:17.27V, Imp:3.59A. With each panel you will receive our K009E Solar regulator kit for only [SP62PK1]

SPECIAL LOW PRICE WITH FREE REGULATOR KIT $150

MPPT SOLAR CHARGE CONTROLLER

This auto detect 12/24V-15A Maximum Point Power Transfer (MPPT) switch mode controller will increase the charging rate by 10-30%! ie. it will deliver 100W into a 10V battery (Flat) from a panel with a maximum output of 100W at 17V. Also inc. a 15A Low Voltage Cut-out for voltage sensitive loads.

[MPPT] $65.00

DOWN LIGHT SPECIAL LIMITED STOCK

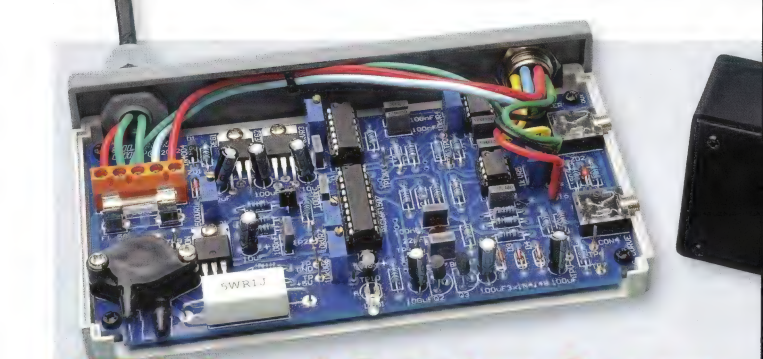
[LEDDL]

This Crompton brand down light has a built in 240V-12V switch mode power supply. It has a swivel head and is supplied with a 4W LED MR16 style lamp.

ONLY $15

www.oatleyelectronics.com Orders: Ph (02) 9584 3563, sales@oatleyelectronics.com, PO Box 89 Oatley NSW 2223

major credit cards accepted, Post & Pack typically $7 Prices subject to change without notice ACN 068 740 081 ABN18068 740 081



Wideband Oxygen Sensor Controller Mk.2

Accurately measure air/fuel ratios with an improved oxygen sensor

Are you involved in car modifications? Have you improved the inlet air-flow or modified the exhaust line with new mufflers? Has your engine been "re-chipped" to improve the timing and fuel parameters or have you fitted bigger injectors? If you answered yes to any of these, then you need to check that your engine is not running too lean or too rich. To do that you need to fit a wideband oxygen sensor and build our improved Wideband Oxygen Sensor Controller.

BACK IN SEPTEMBER and October 2009 we published the original and very popular Wideband Oxygen Sensor Controller. This was designed for use with the Bosch LSU4.2 wideband oxygen sensor. In this substantially revised design, we use the much-improved Bosch LSU4.9 sensor which supersedes the LSU4.2. This has necessitated an upgraded microcontroller, the addition of a sensor to monitor exhaust pipe pressure and a re-designed LED display module.

Most modern vehicles include a narrowband oxygen sensor so that the engine control unit (ECU) can control the air/fuel ratio. Unfortunately, that sensor is only accurate when the fuel/air mixture is stoichiometric, ie, when the mixture is exactly right to give complete combustion and with all the oxygen used in the burning process.

The engine control unit (ECU) normally adjusts the fuel mix to maintain an oxygen sensor signal that's close to 450mV, the stoichiometric point. In practice, a narrowband sensor has a very sharp voltage change around the stoichiometric point and so the sensor voltage is continually cycling above and below 450mV as the ECU maintains the fuel mixture.

This is referred to as "closed loop" operation. It does not matter to the ECU that the narrowband sensor is inaccurate and non-linear outside closed loop operation.

To explain further, Fig.1 shows the typical output from a narrowband

Pt.1: By JOHN CLARKE

oxygen sensor. It has a very sharp response either side of the stoichiometric point (lambda of 1), ranging from about 300mV up to 600mV; the classic "S" curve. For rich mixtures, it ranges from around 600mV to almost 900mV (lambda up to 0.8), is quite non-linear and varies markedly with temperature. It is similarly non-linear for lean mixtures, ranging from around 300mV down to a few mV (lambda of about 1.15).

To learn about lambda, refer to the explanatory panel later in this article.

The ECU uses its own factory preset values to set rich mixtures for acceleration or lean for cruise conditions. This is referred to as "open loop" operation because the oxygen sensor is not capable of providing accurate feedback about the actual fuel mixture.

Now if you haven't changed anything on your vehicle, then there is little reason to worry about the actual fuel mixtures at any time; the ECU takes care of it all. But if you have made any changes to the vehicle to improve its performance (eg, inlet air filter, throttle body and plenum, injectors, MAP or MAF sensor, custom ECU chip, supercharger or turbocharger, catalytic converter, exhaust manifold, mufflers and resonators, in short, anything that's likely to result in significant changes to fuel mixtures and oxygen sensor readings) then you need a wideband oxygen sensor and a companion controller.

Bosch LSU4.9 oxygen sensor

As stated, our new controller is designed to work with a Bosch LSU4.9 wideband oxygen sensor. This sensor is now used in some late-model cars to measure and control the mixtures over the full range of engine operation.

Main Features

- Accurate lambda measurements on 3-digit display
- Pre-calibrated sensor
- Pressure and temperature correction of lambda reading
- S-curve (narrow band sensor) simulation output for ECU
- Heat/data/error indicator LED
- Adjustable engine-started battery voltage threshold
- Correct sensor heat-up rate implemented
- Heater over and under-current shutdown

Fig.2 shows the wideband controller output using the Bosch LSU4.9 sensor over a wide range of air/fuel ratios from 0.7 lambda to 1.84 lambda.

Our Wideband Oxygen Sensor Controller is housed in a small plastic case, as shown in the accompanying photo. As well as providing an 8-pin socket (CON5) for the wideband oxygen sensor, it has two jack sockets. One of these (CON3) drives a companion 3-digit LED display unit which shows the lambda value.

The other jack (CON4) provides a

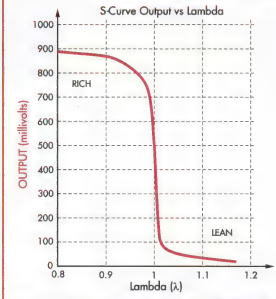


Fig.1: the S-curve output from the Wideband Controller simulates a narrowband sensor output (the response follows the Bosch LSM11 narrowband sensor curve). Note the steep slope in the curve at stoichiometric (ie, lambda = 1).

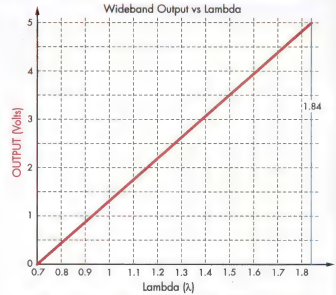


Fig.2: the wideband output from the Wideband Controller is linear with respect to lambda values from 0.7-1.84. The resulting signal is displayed as a lambda value on the Wideband Display Unit to be described in Pt.2 next month.

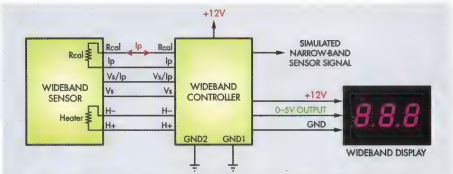


Fig.3: here's how the Wideband Controller is used with a wideband oxygen sensor and with a Wideband Display Unit (to be described in Pt.2), to provide accurate air/fuel mixture readings. As shown, the Wideband Controller has both a display output and a simulated narrowband (S-curve) output.

signal which simulates the output from a narrowband sensor. This enables the vehicle's existing narrowband sensor to be replaced with the Bosch LSU4.9 and still provide for normal ECU operation.

As far as the car's ECU is concerned, the simulated signal is what it would get from a narrowband sensor and so engine operation is normal.

By the way, it's possible to use the wideband sensor by temporarily installing it into the end of the exhaust pipe, as will be detailed in Pt.2 next month. You might want to do this for easy monitoring of changes to different vehicles. However, the ideal installation is to substitute the original narrowband sensor with the Bosch LSU4.9.

A description of the new Bosch sensor is provided in an accompanying panel.

Another feature of our new Wideband Oxygen Sensor Controller is an on-board sensor to measure pressure in the exhaust system. We'll talk more about this later.

A red status LED on the front panel indicates when the controller is heating the sensor to its operating temperature. This occurs each time the controller is switched on and it takes less than 10 seconds for the operating temperature to be reached.

Once the sensor is at operating temperature, this LED then flashes rapidly. From that point on, the wideband controller is monitoring the signal from the oxygen sensor and feeding a simulated narrowband signal to the ECU. By contrast, the LED flashes more slowly if there is a sensor error or if the air/fuel ratio is outside its measurement range.

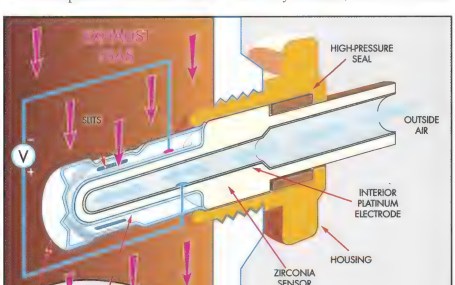


Fig.4: inside a narrowband zirconia oxygen sensor. It consists of a zirconia ceramic sensor element with thin platinum electrodes on both sides.

Why do you need it?

So why is the Wideband Oxygen Sensor Controller necessary? It's because a wideband sensor is very different from a narrowband sensor. In its most basic form, a narrowband sensor has only one wire and this is the sensor output. The other connection is via the metal frame of the unit. However, some narrowband sensors have an internal heater and these units may have three or four wires.

By contrast, a wideband sensor has six wires (yeah, we know the socket on our controller has eight pins – be patient). This is because the wideband sensor comprises a narrowband oxygen sensor, a heater and an oxygen ion pump which diffuses oxygen ions into or out of the measurement chamber (of the narrowband sensor). The heater and oxygen ion pump need to be controlled externally from the sensor and this is where the Wideband Oxygen Sensor Controller comes into the picture. But we are getting way ahead of ourselves . . .

Fig.3 shows the basic set-up. At left is the wideband sensor with its six leads which are all connected to the wideband controller. As already mentioned, this provides a simulated narrowband sensor signal which feeds the ECU. In addition, there is an output to drive the 3-digit Wideband Display Unit.

Before we describe how a wideband sensor and its associated controller work, it's necessary explain the characteristics of a narrowband sensor. Fig.4 shows a cross-section of a typical narrowband sensor. It's about the same size as a spark plug and is threaded into the exhaust system so that the sensor is exposed to the exhaust gasses. The assembly is protected using a shield that includes slots so that the exhaust gases can pass through into the sensor.

The sensor itself is made from a zirconia ceramic material that has a thin layer of porous platinum on both sides. These platinum coatings form electrodes to monitor the voltage produced by the zirconia sensor as the exhaust gas passes through it. For the chemistry-minded, the sensor is called a "Nernst cell".

The device operates by measuring

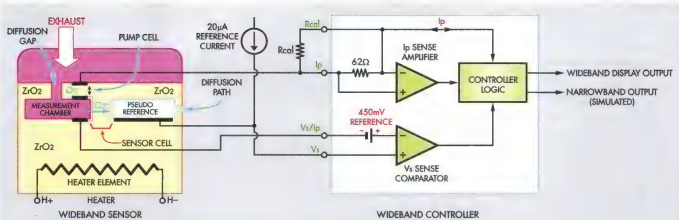


Fig.5: the basic scheme for a wideband oxygen sensor and its associated control circuit (at right).

the difference in oxygen content between exhaust gas and outside air. The oxygen content of air (about 20.95%) serves as the reference (reference air). In operation, a voltage is produced between the electrodes because the zirconia sensor has a high conductivity for oxygen ions at high temperatures.

Some narrowband sensors include a resistive heating element to ensure that they operate within their correct temperature range. The heater also quickly brings the sensor up to its operating temperature and thereby allows the ECU to provide closed-loop operation earlier than would otherwise be possible.

So with that brief description of a narrowband sensor under your belt, take a look now at Fig.5. This shows the internal cross-section of the wideband sensor on the left and the connections to the controller on the right.

The wideband sensor includes a clever method to obtain a wider, more linear response from a narrowband sensor. This involves a measurement chamber incorporating a pump cell into which a small sample of exhaust gas enters via a diffusion gap.

The pump cell moves oxygen ions into or out of the measurement chamber gap in order to maintain a stoichiometric measurement for the sensor cell. For our purposes, the sensor cell is a narrowband sensor. If the measured mixture is lean, then the sensor cell detects excess oxygen. The pump cell then drives oxygen ions out of the measurement chamber until the sensor cell produces a stoichiometric lambda value.

Conversely, if the mixture is rich, oxygen ions are pumped from the surrounding exhaust gas into the measurement chamber gap until the sensor cell again reaches its stoichiometric lambda value.

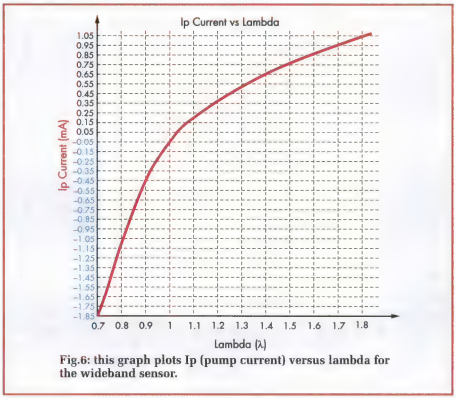


Fig.6: this graph plots Ip (pump current) versus lambda for the wideband sensor.

When the mixtures are lean, there is oxygen available in the measurement chamber for the oxygen ions to be transferred. Conversely, when the mixture is rich, oxygen ions for both the pump cell and the pseudo reference chamber are obtained (reduced) from the available oxygen in the sampled exhaust gas.

This available oxygen can be reduced from exhaust gases such as carbon dioxide (CO_2) and steam (H_2O).

As a result of the above, the current applied to the pump cell can be either positive or negative, depending on whether oxygen is pumped into or out of the measurement chamber. The oxygen pump thus maintains a stoichiometric lambda value within the measurement chamber.

So while the narrowband sensor (sensor cell) is used to detect the stoichiometric mixture, it is the current applied to the pump cell that provides the necessary information to accurately determine the air/fuel ratio.

If this sounds like "black magic" then that's not far from the truth. Most wideband sensors (including the older Bosch LSU4.2) utilise a narrowband sensor similar to the Fig.4 arrangement

Specifications

Power requirement: 11V to 15V. Start-up current when heating is 1.6A (~20W) and typically 0.6A (7.5W) when up to temperature.

Reading accuracy: typically 1%.

Measurement range: 0.7 (rich) to 1.84 (lean) lambda.

Reading error indication: LED flashes at 1Hz rate for <0.7 or >1.84 lambda.

Engine started battery voltage threshold: adjustable to 15V; 13V setting typical (TP2 = 4.17V).

Sensor heating: preheat begins at an effective 2V for 2s then at an effective 7.2V and ramps up at 73.3mV/187.5ms (equivalent to 0.39V/s).

Heater maximum effective voltage (V_{eff}): $12V_{eff}$ after initial preheat and at $13V_{eff}$ for <30s.

Heat-up period: typically <10s.

Heater over current error: 4A.

Fuse protection: 5A.

Heater open-circuit detection error: if current is less than 390mA at initial preheat.

Heater drive frequency: 122Hz.

Sensor temperature: controlled at 780°C by maintaining the 300Ω impedance of the sensor cell at that temperature. Can be measured as 684mV DC at the wideband output with JP1 inserted.

Temperature correction: Ip corrected for sensor temperature between 698°C and 880°C.

Pressure correction: Ip corrected for pressures up to 587hPa above standard atmospheric pressure of 1013hPa.

Pressure offset adjustment: between sea level (1013hPa) and 2000m (766hPa) above sea level. VR6 adjusted for 1V/1000m when the sensor is plugged for gauge pressure readings.

Sensor cell measurement: AC drive at 1.953kHz and 243µA.

Sensor cell DC loading: <4.5µA.

Reference Current: 20µA.

Wideband output: linear 0-5V output for 0.7-1.84 lambda.

S-curve output: simulates a 0.8-1.17 range following the Bosch LSM11 sensor curve.

S-curve response: 100ms time constant.

Wideband reading response: 100ms to a 5% change in oxygen.

Indicator LED: pre-startup and $2V_{eff}$ warm up = dim; during sensor preheat = fully lit; controlled with data = 16Hz flash; error = 1Hz flash. An overheated sensor is indicated with the dim LED.

WHERE TO FIND DATA

(1) Data for the LSU4.2 and LSM11 sensors mentioned is available at **http://www.bosch.com.au/content/language1/downloads/Section_D.pdf**

(2) Data on the Bosch LSU4.9 oxygen sensor is available at **http://www.breitband-lambda.de/media/Dateien%28Lambda%29/LSU49TechProductInfo.pdf**

(3) A description of the operation of wideband sensors and the difference between the LSU4.2 and LSU4.9 is found at **http://www.ee.kth.se/php/modules/publications/reports/2006/XR-EE-RT_2006_008.pdf.junk**

(4) More information on oxygen sensors in general can be found at **http://chemistry.osu.edu/~dutta/index_files/Recent%20Publications_files/Ramamoorthy_R.pdf**

where it has a reference air-chamber. However, the Bosch wideband LSU4.9 sensor does away with the reference air, utilising a "pseudo reference" chamber instead. It is truly a clever device.

For the pseudo reference, excess oxygen is maintained in this chamber by applying a small reference current to the sensor. This current transfers oxygen ions from the measurement chamber to the pseudo reference chamber. For this chamber to act as a reference, the driving reference current must be sufficient to maintain excess oxygen in the pseudo reference chamber.

As with the pump cell, this oxygen comes from the exhaust gas. The partial gas pressure between the two chambers is equalised by having a diffusion path opening in the pseudo reference chamber.

The pseudo reference chamber is a big advance because a reference air-chamber needs to be constantly replenished with oxygen from the outside air and the only way oxygen can enter the sensor is via the sensor leads, ie, between the copper wire and its surrounding insulation, a pretty tortuous route!

Any contamination of the sensor leads from oils, tars and fuels can affect the oxygen flow to the sensor. The leads are also susceptible to damage if the sensor lead connections are soldered (instead of crimped), as this will melt the wire insulation sufficiently to seal the wire against oxygen flow. However, for a pseudo reference, oxygen replenishment is not affected by sensor lead contamination since it derives its oxygen via a different pathway.

It should be noted that both the reference air-chamber and the pseudo reference chamber, whichever is deployed, will be depleted of oxygen over time unless it is continuously replenished. That is because any oxygen in the reference chamber will ultimately diffuse into the measurement chamber to balance out the oxygen partial pressure that is higher in the reference chamber (for the chemistry minded, this is due to Fick's First Law).

Now have another look at the block diagram of Fig.5. Vs is the output voltage from the oxygen sensor cell while Ip is the current into or out of the pump cell. At the stoichiometric point, Vs is 450mV and this is compared against a

450mV reference. If Vs is higher than the 450mV reference, the mixture is detected as "rich" and the Vs sense comparator output goes high.

This "informs" the controller logic that Ip needs to change, to pump oxygen ions into the diffusion gap in order to regain a stoichiometric measurement. Similarly, if Vs is lower than the 450mV reference, the exhaust mixture is detected as "lean" and the comparator output goes low. As a result, the controller adjusts Ip to pump oxygen out of the diffusion gap.

Note that if there is no Ip control, the sensor cell behaves like a standard narrowband sensor with an output voltage above 450mV for rich mixtures and below 450mV for lean mixtures. However, with current control, the pump current is adjusted to maintain a 450mV reading from the sensor cell.

Variations in the sensor cell voltage indicate the change in mixture in either the rich or lean direction, while Ip (the pump current) shows whether the mixture is actually rich or lean. A negative Ip indicates a rich mixture and a positive current indicates a lean mixture. The Ip level indicates the lambda value.

Fig.6 shows a graph of Ip versus lambda for the wideband sensor. The lean region curve (lambda from 1-1.84) was developed from a graph of Ip versus oxygen concentration provided in the Bosch LSU4.9 data and the equation: Lambda = [(Oxygen% + 3] +1] ÷ [1 - 4.77 x Oxygen %]. For the rich region, a 4-step graph provided in the LSU4.9 Bosch data sheet is used.

Another calculation is made to convert the lambda value to the voltage required at the wideband output as shown in Fig.2. Similarly, the lambda value is converted to an S-curve response for the simulated narrowband (S-curve) output as shown in Fig.1.

Ip is sensed by measuring the voltage across a 62Ω 1% resistor (in parallel with Rcal). However, during the calibration of each sensor, the actual resistor used by Bosch is 61.9Ω (a 0.1% tolerance value from the E96 range). Rcal is trimmed so that the voltage across this resistor, measured against lambda, is the same for each sensor.

In fact, Rcal can be a value ranging between 30Ω and 300Ω, depending on the characteristics of the individual sensor. The value for Ip shown on the vertical axis of Fig.6 is therefore not the total pump current.

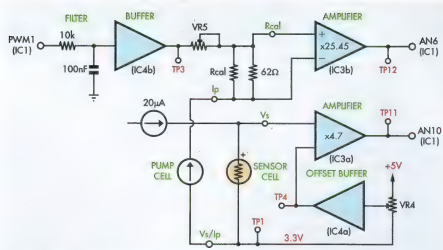


Fig.7: this diagram shows the general arrangement for the pump control and the sensor cell measurement. Buffer stage IC4b supplies current to the pump cell via trimpot VR5 and the paralleled R_{cal} and 62Ω resistors. The other side of the pump cell connects to a 3.3V supply (formed using buffer stage IC2b and set by trimpot VR3 – see Fig.12). IC3a monitors and amplifies the sensor cell voltage (Vs) by 4.7.

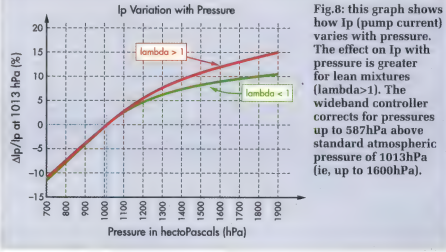


Fig.8: this graph shows how Ip (pump current) varies with pressure. The effect on Ip with pressure is greater for lean mixtures (lambda>1). The wideband controller corrects for pressures up to 587hPa above standard atmospheric pressure of 1013hPa (ie, up to 1600hPa).

In the graph, Ip only relates to the voltage across the 62Ω resistor. So while Fig.6 shows Ip varying between -1.85mA and 1.07mA, the actual total current range could vary from -2.23mA to 1.29mA if Rcal is 300Ω or -5.67mA to 3.28mA if Rcal is 30Ω. This total current needs to be supplied by the wideband controller circuit.

Pump sensor control

Fig.7 shows the general arrangement for the pump sensor control. As can be seen, a filtered pulse width modulated (PWM) signal from a microcontroller (IC1) is applied to buffer stage IC4b. This in turn supplies current to one side of the pump cell via trimpot VR5 and the paralleled Rcal (located inside the wideband sensor) and 62Ω resistors.

The other side of the pump cell connects to a 3.3V supply.

When the output of IC4b is at 3.3V, there is no current through the pump cell. For positive current through the pump cell, IC4b's output goes above 3.3V. Conversely, when IC4b's output is below 3.3V, the pump cell current is negative.

In practice, IC4b's output can swing between 5V and 0V to allow for the current range required for the lambda extremes of measurement (0.7 to 1.84).

The pump cell current (Ip) is monitored using op amp IC3b which operates with a gain of 25.45. Its output is in turn monitored using the AN6 input of microcontroller IC1.

Op amp IC3a monitors and amplifies the sensor cell voltage (Vs) by 4.7. The 20µA reference current is also applied to the sensor cell at this point. Note that while this is called a reference

Advantages Of The LSU4.9 Oxygen Sensor

In September and October 2009, we published a wideband controller based on the LSU4.2 wideband sensor from Bosch. While this sensor is similar in many respects to the LSU4.9, the latter has some distinct advantages.

Perhaps the most important advantage is that the sensor now has a pseudo reference for oxygen that replaces the atmospheric air reference of the LSU4.2. For the LSU4.2, this reference air had to pass through the leads of the sensor and this made it prone to problems due to contamination with oils, tar and fuels preventing the flow of the required oxygen. The LSU4.9 is not subject to any contamination that can cause measurement inaccuracies.

Other advantages of the LSU4.9 over the LSU4.2 are a faster response to mixture changes, a faster heat-up period and a revised higher resistance for the sensor cell. So while the sensor cell of the LSU4.2 has a resistance of 80Ω at its 750°C operating temperature, the LSU4.9's sensor cell is at 300Ω at its operating temperature of 780°C. This higher resistance results in a more accurate measurement of the sensor temperature.

The way in which the LSU4.9 is used with a Wideband Controller also differs from the LSU4.2. While the LSU4.2 heater could be driven from a PWM (pulse width modulated) voltage at 2Hz or more, the recommended heater-driver PWM frequency for the LSU4.9 is greater than 100Hz. Additionally, the ramping up of heating applied to the sensor has been revised to include a preheat at low voltage. These measures ensure that the sensor is not damaged due to thermal shock or from moisture during sensor heating.

Air/fuel ratio & lambda

Lambda is simply the ratio of the actual air/fuel ratio to the stoichiometric air/fuel ratio. For petrol, the stoichiometric air/fuel ratio (the mass of air required to completely burn a unit mass of fuel) is 14.7:1. However, this can drop to 13.8:1 when 10% ethanol is added.

A lambda of 0.7 for petrol is equivalent to an air/fuel ratio of 0.7 x 14.7 = 10.29:1. Similarly, a lambda of 1.84 is equivalent to an air/fuel ratio of 27.05:1. The stoichiometric air/fuel ratio is typically 15.5:1 for LPG and 14.5:1 for diesel. These values can differ depending on the actual fuel composition and for diesel it varies between winter and summer.

Lambda is probably the best measure of air/fuel mixtures since it is a universal value and not dependent on the specific fuel.

current, it is not a critical value and the word "reference" indicates that the current is for the pseudo oxygen "reference".

Note also that any variation in the reference current does not affect the calibration of the wideband sensor when it comes to accurately measuring the oxygen content in the measurement chamber. Instead, that calibration depends on the Rcal adjustment. The reference current must be sufficient to constantly maintain excess oxygen in the pseudo reference. The recommended current to do this is 20μA.

Trimpot VR4 is used to provide an offset voltage which is buffered by IC4a and is set so that IC3a's output is 2.5V when the sensor cell voltage is 450mV. The microcontroller monitors IC3a's output at its AN10 input and varies the pump current to maintain a 2.5V reading. This effectively maintains the sensor cell for monitoring stoichiometric mixtures.

The measured Ip value when the sensor cell is measuring stoichiometric is used to determine the lambda value.

One complication with Ip is that it is dependent on exhaust pressure which is always above atmospheric pressure. Fig.8 shows the change in Ip versus pressure. As a result, our Wideband Oxygen Sensor Controller provides pressure correction up to 587hPa above standard atmospheric pressure (1013hPa).

At this pressure, Ip is reduced by 12% for lean mixtures and 9% for rich mixtures.

This correction requires an air-hose connection from the exhaust manifold to the Wideband Controller. It is optional though. If you don't utilise pressure correction, then the readings can be manually corrected using the graphs of Fig.6 and Fig.8.

Note that the exhaust pressure does not have any effect on stoichiometric readings because Ip at stoichiometric is zero.

Another complication is that Ip is also dependent on temperature. As a result, any variation in the sensor cell temperature will affect the Ip readings, resulting in inaccurate lambda values.

Fig.9 shows how the sensor cell resistance varies with temperature. The change in Ip with temperature is some 4% per 100°C.

There are two ways to ensure the lambda readings remain accurate. One way is to correct for the effect of temperature using the graph and the 4% change per 100°C. We actually do this in the Wideband Controller itself but it is only useful for small temperature changes when variations in exhaust gas flow across the sensor can cause a momentary temperature variation.

The main method to ensure accurate readings is to maintain a constant temperature for the sensor. That's done by using the sensor's heater.

Heater element control

In this case, the Wideband Controller maintains the sensor's temperature at 780°C. In operation, its temperature is measured by monitoring the impedance of the sensor cell. This has high impedance at room temperature, falling to 300Ω at 780°C.

The impedance of the sensor cell is measured by applying an AC signal to it. Fig.10 shows the circuit arrangement. A 5Vp-p (peak-to-peak) AC signal is applied to the sensor cell via a 220nF capacitor and 10kΩ resistor. The capacitor blocks DC and the resistor forms a voltage divider with the impedance of the sensor cell.

When the sensor cell has an impedance of 300Ω, the voltage swing across it is 145.6mV peak-peak. IC3a has a gain of 4.7 so its output is 684.5mV peak-peak. The microcontroller measures this 684.5mV signal at its AN10 input and maintains the 300Ω sensor impedance by controlling the heater current.

Fig.11 shows the heater control circuit. Mosfet Q1 is connected in series with the heater element across the 12V supply and is driven by a PWM signal from IC1 (RB7). The heater current is monitored via a 0.1Ω resistor in series with Q1's source and the resulting voltage across this resistor is filtered using a 22kΩ resistor and 100μF capacitor and fed to input AN4 of the microcontroller. If the heater is disconnected or goes open circuit, the lack of current will be detected and this will switch off the Wideband Controller.

Similarly, if the heater current be-

comes excessive, the controller will switch off Q1 and the heater.

Note that there is a strict "ramp-up" of power that must be applied in order for the sensor to be heated gradually. This is to prevent thermal-shock damage to the ceramic sensor.

It works like this: initially, the sensor is not heated until the engine starts and this allows any condensation to be blown out of the sensor. Then there is a sensor preheat period that begins with an effective 2V being applied to the heating element for two seconds. The heater voltage then increases to an effective 7.2V which then ramps up by 73.3mV every 187.5ms.

This is equivalent to 0.39V/s and just under the maximum ramp-up rate of 0.4V/s specified by Bosch.

In order to set the effective heater voltage, we also have to monitor the battery voltage to calculate the required duty cycle of the PWM waveform. In addition, the battery voltage is monitored to detect when the engine has started.

Basically, the circuit detects when the battery voltage rises above its normal resting voltage with the engine is off. This rise occurs when the engine is started and the alternator begins charging the battery. In practice, the battery voltage can vary from around 12.5V with the engine off to more than 14V when the battery is charged.

As shown in Fig.11, the battery voltage is measured using a voltage divider comprising 20kΩ and 10kΩ resistors, together with a 100nF capacitor to filter out voltage spikes.

In operation, the impedance of the sensor cell is constantly monitored and as soon as it reaches 300Ω the preheat is complete and power to the heater is controlled to maintain this value. Once the sensor has reached operating temperature (780°C), the pump control circuit begins to operate.

Circuit description

Refer now to Fig.12 for the complete circuit details. It's based on a PIC16F1507-I/P microcontroller (IC1) and we have used nine of its 10-bit analog-to-digital (A/D) converters and three of its PWM outputs. It runs with an internal 16MHz clock oscillator.

The remainder of the circuit consists of a pressure sensor, Mosfet Q1 (to control the oxygen sensor heater), some op amps and a few other components.

The op amps are rail-to-rail types

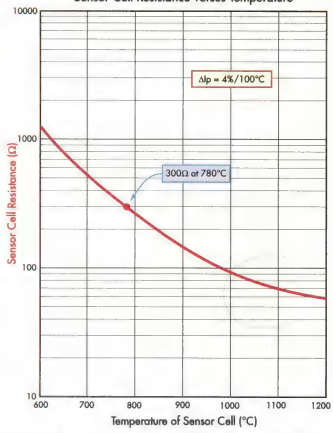
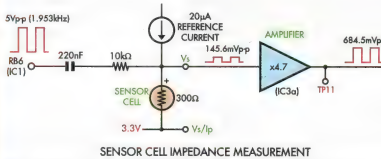
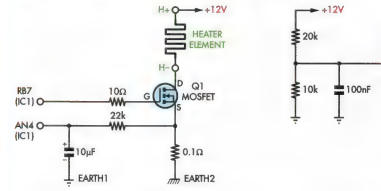


Fig.9: this graph shows how the sensor cell impedance varies with temperature. The change in Ip with temperature is about 4% per 100°C.



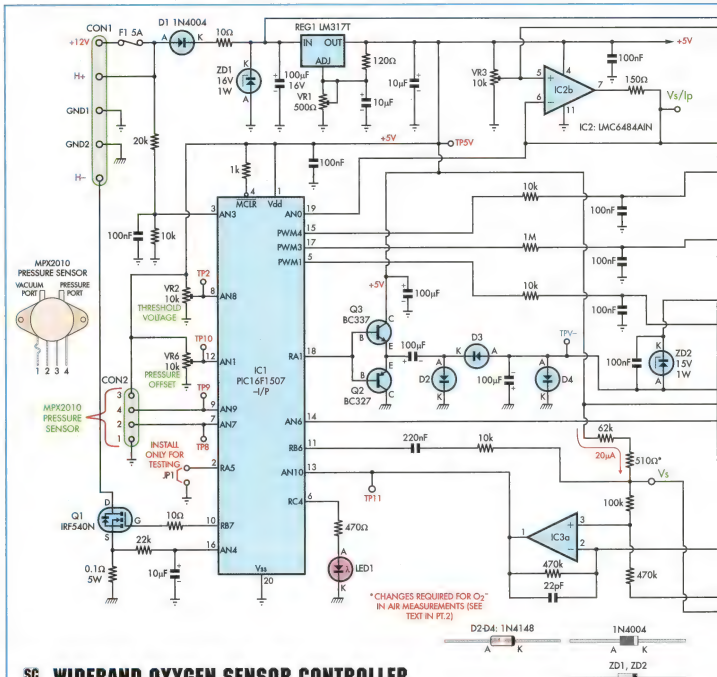
SENSOR CELL IMPEDANCE MEASUREMENT

Fig.10: the temperature of the sensor cell is monitored by measuring its impedance using the circuit configuration shown here.



HEATER CONTROL

Fig.11: the heater element is connected in series with a Mosfet (Q1) that switches the power on and off at 120Hz. Temperature control is achieved by driving the Mosfet with a PWM signal to vary its duty cycle.



SC 12012 WIDEBAND OXYGEN SENSOR CONTROLLER

Fig.12: the full circuit uses microcontroller IC1, several CMOS op amps (IC2-IC4), a Mosfet (Q1) to control the heater in the oxygen sensor and a pressure sensor. The microcontroller and op amps monitor & control the wideband oxygen sensor and drive the Wideband Display Unit. IC1 also provides a simulated narrowband output (via IC2c).

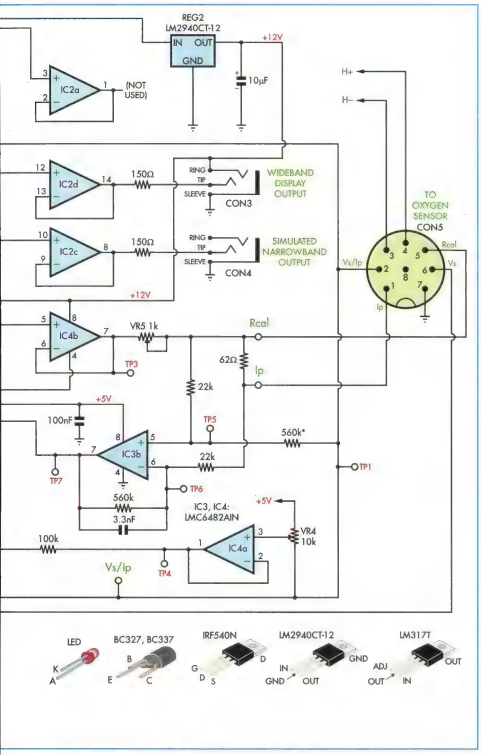
and comprise an LMC6484AIN quad op amp (IC2) and two LMC6284AIN dual op amps (IC3 & IC4). These have a typical input offset of 110µV, a high input impedance of more than 10 Teraohms (>10TΩ), a 4pA input bias current, an output that can swing to within 10mV of the supply rails with a 100kΩ load, and a wide common mode input voltage range that includes the supply rails.

Power for the circuit comes from an external 12V supply, ie, the car battery. The +12V rail is fed in via fuse F1 and applied directly to the heater circuit (via H+ at CON1). It's also fed in via reverse polarity protection diode D1 and applied to an LM317T adjustable regulator (REG1) and to 12V regulator REG2 (LM2940CT-12).

Fuse F1 will blow if the sensor is connected when the supply polarity is reversed. That's because, in this situation, there's a low-resistance current path through the heater element and the body diode in Q1.

Trimpot VR1 allows REG1's output to be set to exactly 5.00V. This rail supplies microcontroller IC1 and op amps IC2 and IC3. The +12V rail from REG2 supplies IC4.

The battery voltage is measured at the AN3 input of IC1 via a 20kΩ and



10kΩ voltage divider connected between the +12V input rail and 0V. This divider reduces the applied voltage by two thirds and results in a maximum of +5V at the AN3 input for a battery voltage of 15V (note: 5V is the upper limit for analog-to-digital conversion by IC1 for a maximum 10-bit digital value of 1023).

Trimpot VR3 across the 5V rail provides the 3.3V reference voltage referred to earlier and this is buffered by op amp IC2b. This op amp drives one side of the pump cell, at the Vs/Ip connection, via a 150Ω resistor which isolates the op amp output. In addition, the Vs/Ip voltage is measured at the AN0 input of the microcontroller to ensure that the pump current can be set to zero by applying the same voltage (from the PWM1 output) to pump drive buffer stage IC4b.

This is necessary because zero pump current is required during the sensor heat-up period. It's also necessary when there is a fault in the sensor's heater element or the connection to it.

IC4b is driven from the PWM1 output of IC1 via a 10kΩ resistor and 100nF capacitor. These RC components filter the PWM output to produce a steady DC voltage. The PWM signal is output at 15.625kHz and its duty cycle can be varied from 0-100% to produce an effective DC voltage ranging from 0-5V.

IC1's PWM4 and PWM3 ports (pins 15 & 17) provide the wideband and narrowband signal outputs respectively, again using PWM control. As shown, the PWM4 output is filtered via a 10kΩ resistor and 100nF capacitor and buffered with IC2d. The wideband display output is then fed to CON3 via a 150Ω resistor.

By contrast, the PWM3 output is filtered using a 1MΩ resistor and 100nF capacitor to give a slower, smoothed response that's similar to the response from a standard narrowband sensor. This signal is buffered using IC2c and fed to CON4 via a 150Ω isolating resistor.

Additional supply rails

While IC2 & IC3 are provided with a 5V supply, IC4 is a special case because IC4b's output is required to swing from 0-5V to drive the pump cell with current. To ensure this, IC4's positive supply rail needs to be more than +5V and its negative rail needs to be less than 0V.

As a result, REG2 is included to provide a nominal 12V supply. This supply is nominally 12V because the regulator cannot deliver 12V unless the input is just over 12V. If the input voltage to REG2 is less than 12V, its output falls accordingly.

This isn't important since we only want more than 5V for IC4 and REG2 is basically used to limit the positive supply to +12V.

Transistors Q2 & Q3, diodes D2-D4 and their associated capacitors are used to derive the negative supply rail for IC4. This circuit is driven by the RA1 output of IC1 which generates a 3.906kHz square-wave signal. Q2 & Q3 buffer this signal and drive a diode pump consisting of D2 & D3 and two 100µF capacitors.

This produces a negative supply rail of -2.5V. Diode D4 clamps this rail to

Parts List

1 PCB, code 05106121, 149 x 76mm (availble from Silicon Chip)
1 ABS box, 155 x 90 x 28mm (Altronics H0377)
1 MPX2010DP 10kPa temperature compensated pressure sensor (Sensor1; optional) (Jaycar ZD-1094)
2 M205 PCB-mount fuse clips
1 5A M205 fuse (F1)
1 DIL20 IC socket
1 DIL14 IC socket
2 DIL8 IC sockets
2 3.5mm stereo jack plugs
1 4-way SIL socket strip (can be cut from a DIP8 IC socket)
1 2-way PCB-mount screw terminals (5.04mm spacing)
1 3-way PCB-mount screw terminals (5.04mm spacing)
4 M3 x 5mm machine screws
4 M3 x 10mm machine screws
2 M3 x 15mm machine screws
5 M3 nuts
1 3-6.5mm IP65 cable gland
20 PC stakes
1 2-way pin header, 2.54mm pitch
1 jumper plug for pin header
1 100mm cable tie
1 70mm length of yellow medium duty (2A) hookup wire
1 70mm length of red medium duty (2A) hookup wire
1 70mm length of black medium duty (2A) hookup wire
1 120mm length of green medium duty (2A) hookup wire
1 150mm length of light blue heavy duty (7.5A) hookup wire
1 4m length of green heavy duty (7.5A) hookup wire
1 2.5m length of red heavy duty (7.5A) hookup wire
1 140mm length of 3mm heatshrink tubing (or 20mm yellow, 40mm red, 40mm black, 40mm green)

Semiconductors

1 PIC16F1507-I/P microcontroller programmed with 0510612A.hex (IC1)
1 LMC6484AIN quad op amp (IC2)
2 LMC6482AIN dual op amps (IC3,IC4)
1 LM317T adjustable regulator (REG1)
1 LM2940CT-12 12V low-dropout regulator (REG2)
1 IRF540N 100V 33A N-channel Mosfet (Q1)
1 BC327 PNP transistor (Q2)
1 BC337 NPN transistor (Q3)
1 3mm red LED (LED1)
1 16V 1W zener diode (ZD1)
1 15V 1W zener diode (ZD2)
1 1N4004 1A diode (D1)
3 1N4148 switching diodes (D2-D4)

Capacitors

4 100µF 16V PC electrolytic
4 10µF 16V PC electrolytic
1 220nF MKT polyester
8 100nF MKT polyester
1 3.3nF MKT polyester
1 22pF ceramic

Resistors (0.25W, 1%)

1 1MΩ	1 1kΩ
2 560kΩ	1 510Ω
2 470kΩ	1 470Ω
2 100kΩ	3 150Ω
1 62kΩ	1 120Ω
3 22kΩ	1 62Ω
1 20kΩ	2 10Ω
4 10kΩ	1 0.1Ω 5W

Trimpots

1 500Ω multi-turn trimpot (3296W type) (Code 501) (VR1)
4 10kΩ multi-turn trimpot (3296W type) (Code 103) (VR2-VR4,VR6)
1 1kΩ multi-turn trimpot (3296W type) (Code 102) (VR5)

Sensor Parts

1 Bosch LSU 4.9 Broadband Oxygen sensor (Available from TechEdge **http://wbo2.com/lsu/sensors.htm** part #17123, Bosch. Part # 0 258 017 123)

1 Bosch connector for LSU 4.9 sensor (Available from TechEdge **http://wbo2.com/cable/connkit.htm** part #017025)

1 6-way sheathed and shielded lead with 2x7.5A wires for heater (Available from TechEdge **http://wbo2.com/cable/default.htm** part #DIY26CBL; includes 1 x 8-pin circular multi-pole line socket part #P8PIN)

1 8-pin circular multipole panel microphone plug connector (Available from TechEdge **http://wbo2.com/cable/connkit.htm** part #S8PIN)

+0.6V when the negative supply generator is not working, ie, when IC1 is not in circuit or if there is a fault in the negative supply generator. Zener diode ZD2 limits the total supply that can be applied to IC4 to 15V.

Op amp IC3b is connected as a differential amplifier to monitor the voltage across the paralleled 62Ω and Rcal resistors. It operates with gain of 25.45 as set by the 560kΩ and 22kΩ feedback resistors. The 3.3nF feedback capacitor rolls off high frequencies and prevents amplifier instability.

IC3b's output is referenced to the Vs/Ip voltage (at +3.3V) by the 560kΩ resistor between its pin 5 input and the output of op amp IC2b. As a result, when there is 0V across the 62Ω resistor, IC3b's output sits at 3.3V.

Sensor cell voltage

Op amp IC3a monitors the sensor cell voltage (Vs). As already noted, IC3a is set so that when Vs is at 450mV, its output is 2.5V.

To do this, trimpot VR4 provides an offset voltage which is buffered using op amp IC4a. A 2.5V setting means that IC3a can swing symmetrically above and below this level to drive IC1's AN10 input (pin 13). This voltage swing allows an expanded measurement of any variation above or below 450mV from the sensor cell.

The reference current applied to the sensor cell is derived via two series resistors (62kΩ and 510Ω) between the +5V supply rail and the Vs terminal of the sensor cell (in the oxygen sensor). When the controller is running and measuring correctly, the Vs terminal is at the Vs/Ip voltage (3.3V) plus the 450mV of the sensor cell.

The 62kΩ and 510Ω series resistors deliver the recommended 20µA current to the cell. That current is calculated as (5V - 3.3V - 450mV) ÷

(62kΩ + 510Ω) or 19.99μA. The actual current does not affect the accuracy of lambda measurement unless the current is reduced down to near zero or is increased above 40μA.

Link setting

When installed, jumper JP1 ties IC1's RA5 (pin 2) input low. This selects a test mode for checking that the sensor impedance is correct (ie, 300Ω).

In this mode, instead of the wideband output from IC2d providing 0-5V for lambda measurement, it outputs a value that corresponds to the impedance of the sensor cell. Since this impedance depends on the temperature of the sensor, it's useful for ensuring that part of the control circuit is working and that the sensor is not being overheated by exhaust gas when installed in a vehicle.

Trimpot VR2 sets the threshold voltage for "engine-started" detection. This is so that the engine can blow out any condensation in the sensor before any electrical heating of the sensor begins.

As stated previously, engine-started detection is achieved by monitoring the battery voltage. Typically, a 12V lead-acid battery is below 12.9V when the engine is off but rises above 12.9V when the engine starts and the alternator begins charging.

In operation, the battery voltage is compared with the threshold voltage on TP2 (AN8 of IC1), as set by VR2. This threshold voltage can be set anywhere from 0-5V, corresponding to a battery voltage range of 0-15V.

Basically, the TP2 voltage is set to 1/3rd the required engine-started battery voltage. For example, if this voltage is selected to be 13V, TP2 is set at 4.33V.

When the wideband controller is used as a portable air/fuel ratio measuring instrument, TP2 can be adjusted to 4V or less. This will ensure that the sensor is heated when power is first applied. However, it also means that the sensor MUST be protected from moisture ingress and from physical shock when not in use.

Heater current

Mosfet Q1 drives the sensor's heater with a DC voltage derived from a 122Hz PWM signal delivered from IC1's RB7 output (pin 10). The heater current (and the Mosfet's source current) is monitored via the AN4 input at pin 16. That's done by monitoring the voltage across the 0.1Ω 5W resistor.

LED1 is the status LED. It's driven from the RC4 output of IC1 via a 470Ω current-limiting resistor. As stated previously, it turns on when the sensor is heating and then flashes rapidly once the operating temperature is reached. It flashes more slowly if there is a sensor error or if the air/fuel ratio is outside its measurement range.

Pin 4 of IC1 is the MCLR reset input. It's pulled high via a 1kΩ resistor and ensures that IC1 is reset on power up.

Two grounds

Note that the circuit uses two grounds. One (GND2) is for the heater, while the other (GND1) is for the rest of the circuit. These two grounds are connected to the car chassis via separate wires.

Without this separate earthing, the switching current applied to the heater would cause inaccuracies in the measurements of voltage and current and for the wideband output.

Pressure sensing

The pressure sensing circuit comprises the pressure sensor (Sensor1) itself and offset trimpot VR6. The specified sensor has differential pressure inputs and differential outputs. These outputs are connected to AN7 & AN9 (pins 7 & 9) of IC1.

With a 5V supply, each output sits at 2.5V when there is equal pressure on each input port. Unequal pressures result in a differential output of 1.25mV per kPa, although the resolution of the pressure sensor readings with a 10-bit A/D converter is about 3.9kPa (or 39hPa).

This resolution is sufficient to allow Ip to be corrected to within 1%. The highest pressure that we compensate for is 587hPa (58.7kPa) above atmospheric, which gives a differential sensor output of 73.38mV. The resulting correction, as determined by the microcontroller, reduces Ip by 12% for lean values and by 9% for rich values. These corrections are in accordance with the graph shown in Fig.8.

The pressure sensor is set up by plugging (blocking) one of its differential air inlets to allow the sensor to work as an absolute pressure (often called "Gauge pressure") sensor rather than as a differential sensor. This is best done when the sensor is located at sea level, where the standard air-

This is the Bosch LSU 4.9 wideband sensor that's used in conjunction with the Wideband Controller.

pressure of 1013hPa is available. That way, the sensor will respond to variations in pressure above and below standard atmospheric pressure, giving a positive output for pressures above atmospheric and a negative output for pressures below atmospheric.

If one input is plugged at higher altitudes, the sensor output will be referenced against the lower pressure in the plugged inlet and the actual output will be a positive value when measuring standard atmospheric pressure instead of 0. In other words, the pressure sensor output will be offset according to the amount that the plugged input is below atmospheric pressure.

As a result, offset trimpot VR6 has been included to counter this effect. Basically, it allows the lower pressure reading to be offset, not at the sensor itself but in the way the sensor's output is mathematically manipulated by the software.

In practice, VR6 is set to give a 1V output per 1000m above sea level. For a sea level setting, its output (TP10) is set at 0V. At higher voltage settings, IC1 provides compensation for the approximate 11kPa drop in pressure per 1000m in elevation above sea level.

Note, however, that this only applies for elevations up to 2000m above sea level, at which point the change in pressure becomes non-linear. As a result, we do not correct for pressure offset above 2000m.

If the pressure sensor is not required, then the AN7 and AN9 inputs must be tied to 0V and 5V respectively. That will stop the AN7 and AN9 inputs from floating and will also indicate to IC1 that the sensor is not connected.

We show how these AN7 and AN9 inputs are tied to the supply rails in the construction details to be published next month. We'll also publish the details for the display readout. SC

SERVICEMAN'S LOG

Off on yet another wild goose chase

Dave Thompson*

It's always important to gather as much information as possible from the customer before starting a repair, otherwise it's all too easy to get involved in a wild goose chase. Here's a classic example of what can happen.

Items Covered This Month

- Rockit PA/instrument amplifier
- Jansen PA/instrument amplifier
- Faulty voltage/current calibrator
- The ignorant customer and his new 500GB hard drive

*Dave Thompson, runs PC Anytime in Christchurch, NZ.

A MUSICIAN FRIEND of a friend recently contacted me, asking if I would check out two PA/instrument amplifiers that weren't working properly. I replied that given the economic climate here in Christchurch, I'd look at anything!

Unfortunately, I wasn't at the workshop when he dropped the amplifiers off so I didn't get to ask my usual pointed questions. As any serviceman can tell you, asking the right questions when the gear is brought in can often save a lot of time and grief further down the track. Of course, I did get some of the background over the phone but there were quite a few questions remaining.

As for the units themselves, one was a Rockit 150W 8-channel mixer/amplifier combo which his band used for the front-of-house vocal mix. The other was a Jansen 440W bass guitar amplifier. In most gigging bands, one person typically ends up doing all the PA-related set-up and in this band, the job falls to the guy who dropped the amplifiers off. He's also the band's bass guitarist and apparently is the only one who knows how to put it all together.

His descriptions of the amplifier faults were a little on the vague side though. He'd told me over the phone that there were problems with both amplifiers but didn't go into great detail. When he dropped them off, he told my work colleague that the Rockit's monitor system had stopped working and the bass amplifier sometimes squealed loudly when fired up.

In the end, I decided to call him to find out more specifically what was going on with the amplifiers. I also wanted to ask if he had tried anything to try to isolate the problems, such as trying different cables and speakers with the Rockit.

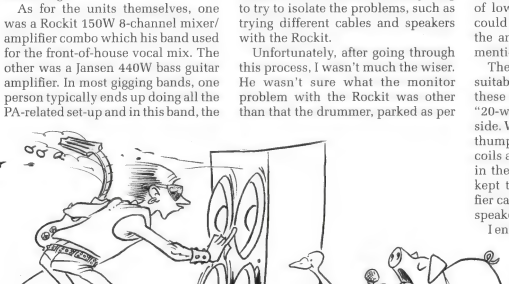
Unfortunately, after going through this process, I wasn't much the wiser. He wasn't sure what the monitor problem with the Rockit was other than that the drummer, parked as per usual at the back of the stage, couldn't hear anything through his foldback wedge. They hadn't tried any other cables or speakers and he had simply assumed it was something to do with the amplifier.

As for the bass amplifier, all he knew was that sometimes he'd arrive at a gig, plug everything in and when he turned it on, he would get an alarmingly loud squeal through his "quad" (a large bass speaker cabinet sporting four 12 or 15-inch bass drivers). Given this amplifier pumps out a hefty 440W of low-end grunt, this type of fault could pose serious consequences for the amplifier's output stages, not to mention the speakers.

The first issue I faced was finding suitable speakers with which to test these amplifiers, as my workshop "20-watters" are a touch on the small side. With units like these, a power-on thump can blow low-wattage voice coils and/or leave the cones dangling in the frames. Even if the volume is kept to a minimum, a faulty amplifier can still send a nasty signal to the speakers and I wasn't about to risk it.

I ended up calling the band's drummer and he offered to drop off a foldback wedge, which sounded perfect (no pun intended!). If I was going to blow speakers, I may as well blow theirs!

Fortunately for me, the two amplifiers were both made in now-defunct Auckland factories in the mid-1980s and were pretty much standard



~HE WOULD GET AN ALARMINGLY LOUD SQUEAL THROUGH HIS "QUAD"...

fare. The Rockit used a transistor output stage (similar to many of the kit-set power amplifiers of the day) while the Jansen used a bank of Mosfets. Both used analog preamps stuffed with op amps like the TL071 and RC4558 and all other passive and discrete components were clearly marked.

It certainly makes it easier when parts can be easily identified, especially when circuit diagrams are hard to find.

I fired the Rockit up first. To test amplifiers, I use my trusty signal injector which I made from a SILICON CHIP project many years ago. This was housed in a cylindrical metal vitamin container and I mounted a push-to-make switch on the plastic cover. A sharpened probe, salvaged from an old multimeter lead, was mounted through a hole drilled in the opposite end, while the earth lead was brought out through a grommeted hole in the side of the tube and terminated with an insulated crocodile clip.

The result is a very useful piece of test gear that can be operated using just one hand.

Anyway, I connected a 6.3mm mono jack plug (the music world's universal instrument input connector) with a flying lead to one of the Rockit's eight inputs, clipped the crocodile clip of the signal injector to a ground point on the chassis and set the channel and master volumes just above the stops. I then touched the injector's probe onto the input lead connected to the jack plug and pressed the button.

When I did this, a nice clean tone came from the speaker so the amplifier chain was working OK and the volume wasn't high enough to frighten the daylights out of me. All I had to do now was to figure out why the monitor side of things wasn't working.

Now whenever I get old units like this coming in for repair, I always suspect that a solder joint has degraded and formed a dry joint or perhaps a connecting wire might have come adrift. These types of amplifiers are usually very well built for the road but unlike their domestic sit-in-the-lounge cousins, they tend to suffer some terrible abuse.

Indeed, I know from my own days of touring with five other musos, travelling endlessly up and down the country in a van stuffed with audio hardware, that the gear often gets a very hard time. Unloading and reloading audio gear before and after a gig is not exactly an enjoyable exercise and the amplifiers and speakers tend to get the odd bit of "road rash" now and then. This can play havoc with physical connections and soldered joints.

Anyway, having established that the amplifier worked, I unplugged it from the mains, removed the machine screws holding the front and rear panels and slid the whole kit-n-caboodle out of the road case (I love this method of construction – everything is so easy to access). I then set the two halves up on the bench and had a good look over them, paying particular attention to interconnecting cables and solder joints.

Now although I love a good electronics detective mystery, the serviceman inside me is always looking for a quick-and-easy fix rather than a drawn-out and ultimately uneconomical repair. There was no such luck in this case – the interior of this amplifier looked pristine, without so much as a spider's web evident. In fact, the components all looked as-new, despite pushing 30 years

NEW 4 Digit UP-DOWN Counter Module with Preset Feature

The **MXA069** (0-9999) UP/DOWN Counter features power drivers to multiplex JUMBO LED displays, up to 10". Adding more MXA069 increases the count capacity by 4 digits at a time. Hundreds of applications in sport,traffic, automation and industrial control

Value!!!

Fully Assembled and Tested

$38.17 inc. GST

Plus **$7.50 Pack & Post**

NEW 5 Channel Infra-Red Remote Control Kit Set with Handpiece

Build your **FK442** to control appliances, lighting, air-conditioning machinery and security systems. The 5 channel receiver board is user-set to match the hand piece numeric settings, and the relays can be set for momentary or ON-OFF-ON control. **Add up to 5 receiver** boards to control **30 x 500Watt relays** from a single point.

Single Channel Kits Available

All Up!! $48.34 inc. GST

Plus **$7.50 Pack & Post**

For details and to buy on-line see us at:

www.kitstop.com.au

P.O. Box 5422 Clayton Vic.3168

Tel:0432 502 755

KitStop electronics – the fun starts here

Radio, Television & Hobbies: the COMPLETE archive on DVD

- **Every issue individually archived, by month and year**
- **Complete with index for each year**
- **A must-have for everyone interested in electronics**

This remarkable collection of PDFs covers every issue of R & H, as it was known from the beginning (April 1939 – price sixpence!) right through to the final edition of R, TV & H in March 1965, before it disappeared forever with the change of name to Electronics Australia.

For the first time ever, complete and in one handy DVD, every article and every issue is covered.

If you're an old timer (or even young timer!) into vintage radio, it doesn't get much more vintage than this. If you're a student of history, this archive gives an extraordinary insight into the amazing breakthroughs made in radio and electronics technology following the war years. And speaking of the war years, R & H had some of the best propaganda imaginable!

Even if you're just an electronics dabbler, there's something here to interest you.

NB: Requires a computer with DVD reader to view – will not work on a standard audio/video DVD player

Use the handy order form included in this issue

THEY CAN WANDER QUITE A BIT WITH AGE TOO!

old and all the visible solder joints appeared shiny and electrically sound.

Oh well; you win some and you lose some.

As mentioned above, the rear section of these amplifiers usually carries all the output sockets and this one was no different. In this case, there are two main speaker outputs, as well as an echo/effects send/return loop, a monitor output for a foldback system and a "slave" output for daisy-chaining this amplifier to another power amplifier.

All these outputs are line-level outputs. In addition, the echo/effects loop and monitor outputs have separate controls on each channel to determine how much signal from the preamp stages is fed to the relevant system.

I plugged a pair of headphones into the various output sockets and all appeared to be working as they should. However, when I listened to the low-level monitor feed, alarm bells began to ring (figuratively speaking that is).

The foldback speaker I was using was one of their usual stage units. However, there was no way this line-level monitor output was going to drive this speaker at any volume without something else in the system to boost the signal. I called the bass player again and asked him if they had another monitor amplifier somewhere. He said they didn't but I should ask the drummer because he usually plugged in his own monitor speaker (the one I had at the workshop) and the bass player wasn't 100% certain how he plugged it into the PA system.

Now at last we were starting to get somewhere. The bane of a serviceman's existence is misinformation and it seems that I had been getting the wrong end of the stick. A call to the drummer confirmed that he didn't plug his monitor into the monitor output of the PA amplifier but into a bridged speaker socket on one of the front-of-house speaker bins instead!

In practice, this made both more and less sense. When wired up this way, his foldback speaker was simply an extension or slave speaker for one of the main FOH (front-of-house) speakers. This meant that he was simply hearing whatever mix was sent to FOH speakers. However, this also explained why he couldn't alter the volume of his monitor and why he got a lot of feedback from that wedge, requiring him to position it very carefully.

It turned out that just like the band I was in, the left hand doesn't always know what the right hand is doing and in hindsight I should have spoken to everyone concerned as to the exact system they used. This new information meant that there was nothing wrong with the Rockit amplifier at all. Instead, the problem was most likely a dud speaker lead or a broken socket in the main speaker and I decided to check that out later.

After talking with the drummer, I offered to build him an active (powered and amplified) foldback speaker. This would take the monitor output from the Rockit as intended and would enable him to control his own volume and audio mix. He replied that this was exactly what he'd been wanting for the last 10 years but didn't know how to achieve it.

So at least something good came of the whole Rockit affair. At the same time, it also had a decent check-up and they now know it will keep pumping out the sounds for a while yet.

On to the Jansen

With the Rockit affair out of the way, I hoisted the Jansen amplifier onto the bench. This sucker has a very large power transformer, which makes it a beast of a thing to carry around.

I powered it up numerous times but couldn't replicate the squealing noise the bass player had reported. I then pulled it apart and connected the two halves back together on the bench without the road case.

This amplifier was also quite tidy inside, though a little dustier because it had a cooling fan that sucked dust in along with the cooling air. Considering this amplifier would have done the majority of its work in smoke and sweat-filled pubs and clubs over the years, I was surprised not to find a layer of nicotine-impregnated oil and dirt coating every interior surface. In fact, this type of contamination sometimes makes working on sound hardware a disgusting task.

As before, I checked all the usual suspects and made sure the interconnecting cables and their connections were secure and electrically sound. It all seemed fine until I took a closer look at the preamp board and immediately noticed a tiny sliver of metal sitting between pins 1 & 2 on one of the TL071 op amps.

A closer look through my trusty magnifying glass confirmed it. If I bumped the case, I could see the sliver move, so it could easily be shorting out pins 1 & 2 of the chip due to vibration.

I used a pair of tweezers to remove the metal sliver and under the right

The faulty voltage/current calibrator

A. L. from Turramurra, NSW went bargain hunting in Singapore but got more than he bargained for. Here's his story . . .

Last year, my wife, daughter and I had a holiday in Singapore. While we were there, my wife and daughter decided to take off one day for some bargain shopping. Having been caught on these expeditions before, I said that I would do the same thing only with electronic bargains, so I headed straight for Sim Lim Tower then Sim Lim Square which is diagonally opposite.

The "Tower" is a rather strange place and has several floors of small shops, each of which specialises in a certain line. For example, there are shops selling just capacitors – everything from SMD miniatures to giant, oil-filled, multi-kilovolt jobs. I bought a few kilograms of some large electrolytic capacitors and high-voltage capacitors very cheaply indeed!

Other shops specialise in audio-visual parts, switches or just connectors and I also bought a few kilos of these, as well as some hard-to-get items.

I also checked out one of my favourite shops on the third floor which specialises in electronic tools. I had bought a couple of instruments there once before and have been very happy with them.

This time around, they had two voltage/current calibrators in the window which looked like value for money and so I asked the proprietor which one he considered the best. He told me that "cheap one only works sometimes but this one is OK!" and so we checked it out on a couple of multimeters and it performed well.

And so after some customary bargaining, I purchased it and took it back to the hotel.

The brand is a Victor 04 Voltage/mA source but I have seen the same thing on the internet under different names and sure enough, it is made in China. It looks much like an electronic multimeter but instead of measuring voltage or current, it delivers a very accurate voltage or current so that you can check and calibrate your multimeters.

For example, you can set the output voltage anywhere from 1mV to around 8V with an accuracy of 0.5mV. It can also provide a constant current ranging from 0.001mA to 22mA to allow current calibrations.

Overall it is a very handy tool because just like us, most multimeters suffer from heat exposure, vibrations, moisture or being dropped. They can wander quite a bit with age too!

On returning home, I checked all my multimeters and two of them went straight into the quarantine box because they were significantly out of whack by over 1V DC! I also checked it against my 8-digit Agilent 3458A bench multimeter and sure enough, the calibrator was very accurate!

Some weeks later, I decided to use the instrument to check and calibrate DC measurements on an oscilloscope. I hooked it up but I couldn't get any stable readings so I checked it against the bench multimeter and also couldn't get anything stable. So it looked like the unit had developed a fault during the period it had been left unused.

Not having any sort of international guarantee and not intending to return to Singapore in the near future, I decided to see if I could fix it myself. First, I checked the manual for some sort of fault-finding table but all I found was: "A note stands to remind the user that he misunderstand the correct operation of the calibrator and its characteristics".

They stand in pretty good judgement of me on that issue!

And as for any disassembly instructions, it states that "no-one is allowed to remove the split case except professionals",

Well, so much for the manual. But I think I qualify as a professional case splitter!

Changing the battery made no difference and I almost feared that the instruments under test were faulty. I then noticed that jiggling the calibrator's leads and holding them upright seemed to fix the problem, so I decided to remove the leads and replace them with known good ones. However, when I pulled out the common (negative) lead, the internal spigot came free of the circuit board!

On splitting the case, it was pretty obvious that the soldering was poor. It had a dry "crystalline" appearance and no strength at all. So as accurate and well-designed as these instruments are, they leave something to be desired in the quality-control department when it comes to the soldering.

After "sweating" the spigot back in place with a hot iron and also re-soldering the other three spigots, the calibrator performed faultlessly. In short, it was an easy fix but it was unexpected in such a new instrument. Indeed, it would be very rare to see anything like this happen with a well-known brand, so bargain shopping has it risks.

Having got the unit working again, I decided to put it to use. One multimeter that was significantly way out on its DC voltage readings was a Jaycar QM-1324. I'd had it for some time and it had had a pretty rough life in the tool box.

When I opened it up, I found that six adjustments were visible, these being labelled VR1-VR6. Without knowing which preset did what, my approach here was to connect the calibrator, set its output voltage to 3.000V and then very gently adjust each of the presets to see if the reading changed.

On the DMM's 20V range, the initial reading was 4.20V but adjusting VR3 made no difference so I returned it to its original position. VR2 gave the same result but VR1 allowed me to adjust the reading to show exactly 3.00 volts

Then, leaving VR1 alone, I tried the same thing with other measurements with the following results: VR2 = °C, VR4 = inductance, VR5 = capacitance. These ranges were calibrated against an accurate LCZR instrument and so the Jaycar multimeter was given a new life.

Finally, most brand new multimeters that I've checked are accurate to ±2mV when fitted with fresh batteries. So if you buy one from a reputable supplier, you can check/calibrate your multimeter against it without having to spend hundreds of dollars on a calibrator. Just make sure you don't knock it or drop it!

IT WAS OBVIOUS HE DIDN'T HAVE A CLUE...

light and magnification could see that it was a curved piece of swarf. Just where this might have come from is a bit of a puzzle as there are no case screws or mounting points anywhere near this chip (metal swarf can sometimes be produced when case screws are overtightened).

The chip was in the active cross-over section of the circuit and all the evidence made sense. I looked over the rest of the boards for more foreign objects and finding none, buttoned it all back up.

The guy has had the amplifier back for a while now and I haven't heard anything during that time. So apparently that was it.

The ignorant customer

All technicians have to deal with self-righteous, uninformed (read ignorant) customers on occasions. G. R. of Mosgiel, NZ recently encountered one such customer . . .

I often wonder why some people insist on doing their own computer repairs or upgrades when they really don't know what they are doing.

Last week, I sold a 500GB IDE hard-drive to a guy via eBay and as soon as he got it, he began complaining via both email and feedback that the drive did not work. Now, I knew that it did work. What's more, it had been supplied zero-fill formatted in an anti-static bag with a silica-gel sachet, complete with a printed report.

Unfortunately, the customer kept demanding his money back and seemed to be totally convinced that I had ripped him off.

After a bit of investigation and advice via email, such as telling him how to find disk-manager and how to quick-format the drive, he still insisted that the machine would not work and that Windows would not even start. So where to start? Perhaps his motherboard's BIOS had a problem with large-capacity drives, so I asked him to return the drive and to bring along his computer as well. This would enable me to see if I could work out what was going on.

The customer lived nearby and eventually, after some persuasion, agreed to do this. However, he was still insisting on his money back, as I would not be able to make it work either – or so he thought.

He arrived the next day with the computer box under his arm. I immediately saw that it was a small-form-factor (SFF) box, which rang alarm bells. When I opened it up, I found that he had installed the new drive correctly but because it is an SFF box, it only has one drive-bay. This meant that he had removed the original drive – the system drive – in order to install the new one but had neglected to then reinstall the operating system.

It was obvious that he didn't have a clue that this was even necessary. Instead, he simply complained to me that the machine would no longer boot up and was convinced that I had sold him a dud. Sheesh . . .

Fortunately, he had brought the old drive with him, so I reinstalled it and sent him away with a USB-IDE adapter for the new drive and then he was happy.

So are you ready for the kicker? He earlier told me on the phone that he had already taken it to a technician and he couldn't make the drive work either!

Frankly, I don't believe him. No technician worth his salt would miss something as simple as that, no matter whether the drive was internal or external. I think that he just blatantly lied to me about that in an attempt to get the upper hand.

As I say, some people should realise their limitations and not attempt to do their own upgrades. The annoying thing is, they are always adamant that they are in the right and that you are in the wrong. Not only that but you are also a rip-off artist.

It gets my hackles up when uninformed customers behave like that and try to tell you your job when they don't know what they are talking about. SC

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in SILICON CHIP? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

Jaycar Electronics

Better, More Technical

JUNE CRAZY CLEARANCE

JUNE EDITION

Price valid until 23/06/2012

Check out our range of crazy clearance lines in-store!

Child Monitor/General Surveillance System

Keep an eye on a room full of children and pan across to zoom onto any one of them, or monitor swimming pool, retail showroom, or factory. You can remotely pan or tilt the camera or even zoom in for a closer look.

- 2.4GHz DIGITAL Wireless transmission
- 100m transmission range
- 2.4" LCD monitor screen
- CMOS image sensor (640 x 480 pixels)
- 2 times digital zoom
- 4 separate channels
- Includes power adaptor for both units
- Size: Camera: 112(W) x 109(D) x 133(H)mm Monitor: 68(W) x 26(D) x 149(L)mm

QC-3638 ***Was $299.00***

CRAZY PRICE

$199.00

SAVE $100

Spare 2.4GHz PTZ Digital Camera QC-3637 ***$99.00***

5Ch DMX LED Light Controller

Compact 5 channel controller creates colourful scenes and amazing lighting effects. A good all round controller giving strobe and basic dimming effects. Features six selectable modes with a combination of RGB colour mixing, fading, chasing and sound control.

- 9V plugpack included
- Size: 252(L) x 122(W) x 46(H)mm

SL-3423

NEW

$89.95

1.3MP Wireless IP Camera

View live camera footage on your iPhone® or computer from anywhere there is Internet access. Free management software for PC, iPhone® and Android™ phones, view up to 16 network cameras simultaneously via the PC software. Easy to install and features motion triggered snapshots and pre/post-recording.

- Sends motion detected snapshots to email and FTP
- Resolution: SXVGA (1280 x 960) at 30fps
- Power supply included
- Size: 78(H) x 68(W) x 27(D)mm

QC-3830

$129.00

NEW STORE- TUGGERAH NSW

118 Pacific Highway NSW 2259

Ph: (02) 4353 5016

Lots of Parking Available!

7-in-1 Solar Rechargeable Station Kit

Kit for Kids

Teaches children the ways of powering and charging a vehicles. Assembled into a recharging station and can be transformed into a truck. Comes with all the snap together plastic parts required (no need for glue), a solar panel, micro rechargeable battery and all the other accessories.

- Recommended for ages 8+
- Size (charging truck): 105(L) x 55(W) x 41(H)mm

KJ-8964

NEW

$24.95

True RMS CAT IV Digital Multimeter - IP67 Rated

Measures up to 1,000 volts AC & DC and is rated to Cat IV 600. The meter includes temperature and capacitance ranges, as well as peak-hold and min/max options. Water and dust-proof (IP67) and features a double moulded case. Includes K-type thermocouple.

- 4000 count
- True RMS
- Backlight, data hold
- Size: 182(H) x 82(W) x 55(D)mm

QM-1543

$149.00

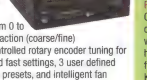
40A Laboratory Power Supply

A high powered switchmode power supply with variable current output from 1 to 16VDC and variable voltage from 0 to 40A. Features dual action (coarse/fine) microprocessor controlled rotary encoder tuning for smooth, precise and fast settings, 3 user defined voltage and current presets, and intelligent fan cooling control. See website for features and specifications.

- High RFI immunity and excellent EMI
- Overload, short circuit, over temperature and tracking over voltage protected
- Size: 200(W) x 90(H) x 215(L)mm

MP-3094

$399.00



Speed Control Kit for Induction Motors

Ref: SC Magazine Apr/Mar 2012

Control induction motors* up to 1.5kW (2HP) to run machinery at different speeds or controlling a pool pump to save money. Also works with 3-phase motors. Full form kit includes case, PCB, hardware and electronics. See website for full features and specifications.

KC-5509

*Note: Does not work for motors with centrifugal switch

Kit will vary from one pictured here.

NEW

$229.00

Motion Activated Outdoor Camera with Flash

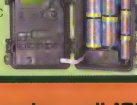
A weather resistant outdoor camera suitable for surveillance around the home, office or warehouse, or for wildlife applications. The PIR sensor with 5-zones for wide angle detection triggers the 7MP camera for colour photos and videos by day or monochrome by night. Night vision is assisted using the bright IR flash, which illuminates objects up to 15 metres away. Photos and videos up to 90 seconds long are recorded to its 32MB internal memory or an SD Card (available separately) for more storage. Playback the vision with audio on the integrated 2.4" colour LCD screen.

- Video resolution: VGA 640 x 480 30fps
- Power: 4 x D and 3 x C batteries required
- Size: 192(L) x 104(W) x 90(H)mm

QC-8036

NEW

$189.00



Mini DVR and Bullet Camera Package

CRAZY PRICE

Record and re-live the thrills of your action sports. Mount the camera and screen on your body, helmet or handlebars, then record video and audio to the 256MB built-in memory or to an SD memory card (1GB - 32GB, not included). Playback on the 2.5" colour screen or output to a larger screen using the AV output. Recharge via USB or using the supplied AC mains charger.

- Colour CMOS camera (curly cord extends to 1m)
- Video Format: AVI (MPEG-4)
- Camera size: 60(L) x 14(D)mm Monitor/Recorder: 75(W) x 55(H) x 20(D)mm

QC-8015 ***Was $269.00***

$199.00

SAVE $70

80 Ch Rechargeable 0.5W UHF Transceiver

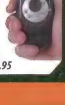
Features a built-in LED torch whilst out in the bush. It does all the normal CB functions and includes desktop charging cradle, AC adaptor, two transceivers and batteries.

- 80 channel
- Power output: 0.5W
- Up to 3km range
- Up to 30 hours battery life

DC-1009

NEW

$69.95



2W 80 Channel UHF Transceiver with CTCSS function NEW DC-1049 ***$99.95***

To order call 1800 022 888

www.jaycar.com.au

Economy USB Digital TV Stick

Digital TV on your PC for under fifty bucks and a bundle of extra features including Picture-in-Picture, still and video image capture and much more. Easy to install.

- Digital TV and radio program recording
- Real-time video recording
- One-touch channel scan
- Multi-lingual installation

XC-4888 ***Was $34.95***

$29.95
SAVE $5

IPTV Internet Digital TV Tuner

Watch your favourite TV shows and schedule recordings from anywhere in the world. Time shifting and scheduled recording are also supported so you can pause and rewind live TV. See website for more details

XC-4861 ***Was $169.00***

CRAZY! CLEARANCE PRICE!

$99.00
SAVE $70

NOTE: Time shifting requires Vista

Touchscreen 8-in-1 LCD Remote Control

Program up to 8 devices in a home entertainment system using the learning function or pre-programmed code library. The LCD backlight is colour coded for easy recognition on each device and key layout can be customise.

- Requires 4 x AAA batteries
- Size: 195(L) x 65(W) x 21(H)mm

AR-1728 ***Was $59.95***

CRAZY! CLEARANCE PRICE!

$39.95
SAVE $20

Class-T Digital Audio Amplifier Module

Ideal for any audio enthusiast that enjoys building and modifying speaker systems. The pre-assembled PCB is tiny which allows you to incorporate it into a wide variety of speaker systems.

- 15W per channel continuous
- Regulated 12VDC 2000mA required
- Size: 68(L) x 32(W)mm

AA-0228

$29.95

IR Over Cat 5 Extender/Repeater Kit

Control AV source equipment up to a distance of 250 metres away with existing IR remote controls over Cat 5 cable. The IR remote signals are piped down the Cat 5 cable for full control at the remote location. Extender, repeater, mains plugpack and emitters included.

- Input: 1 x IR receiver
- Output: 1 x Cat 5, 5 x IR extender
- Power supply: 5VDC, 500mA
- Size: 62(L) x 50(W) x 23(H)mm

AR-1826 ***Was $149.00***

$119.00
SAVE $30

CRAZY! CLEARANCE PRICE!

USB Rechargeable Portable Mini FM Radio with MP3 Player

A compact, portable mini FM radio with built-in MP3 player. Includes rechargeable Li-ion battery. Charge via USB.

- Supports MicroSD card
- USB recharge cable included
- Size: 91(W) x 54(H) x 20(D)mm

AR-1738

NEW
$19.95

MP3 Player Module with Remote Control

A nifty MP3 player module to build into a car or home audio project. Requires 5VDC (via USB port or straight to PCB), and a USB flash drive or SD Card with MP3 files. Features aluminium front panel and bright red LED display.

- Includes slim IR remote
- Size: 75(W) x 49(H) x 46(D)mm

AA-0229

NEW
$14.95

Watch Cable TV All Over The House

Easily share audio and video signals from your cable TV or Blu-ray player with this wireless device. The powerful 5.8GHz transmitter and receiver provide excellent picture and audio quality so you can enjoy your movies or TV shows anywhere in the house without interruption.

- Up to 30m range
- Size: 105(W) x 150(D) x 38(H)mm

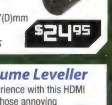
AR-1840

$99.00

BUY a Spare Receiver (AR-1841) for only $30 with every purchase of AR-1840 SAVE $49

SD Digital Set-Top Box with Recording Output

Enjoy more channels, extra features and clearer reception on your analogue TV. Features USB port for AV recording as well as playback.



- DVB-T/MPEG-2 compatible
- Standard definition
- Size: 189(W) x 40(H) x 117(D)mm

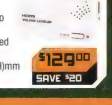
XC-4912

$24.95

Spare remote XC-4911 ***$7.95***

Audio Signal Volume Leveller

Fine-tune your listening experience with this HDMI Volume Leveller. It sorts out those annoying fluctuations in volume while channel surfing or between the TV shows themselves and the advertisements. Protects your valuable home theatre equipment from the damaging noise spikes.



- Regulates TV, satellite, radio and DVD volume
- Mains power supply included
- HDMI in/out ports
- Size: 100(W) x 64(D) x 23(H)mm

AC-1615 ***Was $149.00***

CRAZY! CLEARANCE PRICE!

$129.00
SAVE $20

Portable Headphone Amplifier

Amplify the sound to exactly how you'd like it. Simply connect to headphones of an MP3 player and experience higher quality bass on the go. Designed for high impedance and low sensitivity headphones.

- Requires 1 x AAA battery
- 3.5mm input and output jack
- LED light activation
- Size: 55(L) x 23(W) x 14.5(H)mm

AA-0407

NEW
$19.95

Pro Monitor Headphones

Affordable professional headphones that offers outstanding performance. Provides accurate, linear sound reproduction to cater for the most demanding monitoring applications. Comes with comfortable ear cushions to provide hours of fatigue-free listening.

- Driver diameter: 42mm
- Power handling: 120mW
- Nominal impedance: 64 ohms

AA-2065 ***Was $99.00***

CRAZY! CLEARANCE PRICE!

$79.00
SAVE $20

Mini Rechargeable USB Keychain Speaker

Compatible with any device that features a 3.5mm headphone socket such as iPods®, MP3 players, PDAs, portable games and computers. It comes with a USB connection to recharge the built-in battery.

- Size: 25(W) x 25(H) x 25(D)mm

XC-5178 ***Was $19.95***

CRAZY! CLEARANCE PRICE!

$9.95
SAVE $10

Portable DAB+/FM Radio with Earphones

Never miss your favourite radio stations while you run, cycle or commute. Provides excellent reception and crystal clear digital sound. Equipped with a standard FM radio and requires 2 x AAA batteries.

- Earphones included
- Size: 68(L) x 38(W) x 21(H)mm

AR-1754 ***Was $99.00***

CRAZY! CLEARANCE PRICE!

$59.00
SAVE $40

Audio/Video Balun with DC Power and Wall Plate

Transmit audio and video signals up to 300m over standard CAT5 UTP network cable. Available for both component video and composite video signals with and without audio. All models supplied as a pair.

Composite Video, Mono Sound, DC Power (up to 12V) LT-3037
Was $69.95 Now $29.95 Save $40

Component / RGB Video LT-3038
Was $69.95 Now $29.95 Save $40

Component / RGB Video and Digital Audio LT-3039
Was $69.95 Now $29.95 Save $40

CRAZY! CLEARANCE PRICE!

$29.95
SAVE $40

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/06/2012.

COMPUTER GADGETS

Wireless SD Card - 8GB

Gives a whole new dimension to capturing, storing and sharing of photos and videos wirelessly. Transfer and share precious moments from your digital camera to your PC, laptop, tablets or Smartphones without the need for cables. Great for travellers! See website for full features and specifications.

- 8GB storage for approx. 3000 photos (varies based on photo size)
- Plug & Play

XC-5620

$99.00

Accessories not included

5.5" Graphics Tablet

More comfortable and far more accurate than a mouse with higher resolution and pressure sensitivity. The pen has user defined buttons and "hotspots" around the border of the tablet. Paint, draw, write or touch up. Ideal for graphics designers, photographers or other creatives.

- Battery and software included
- Windows compatible or MAC®
- Size: 205(W) x 190(H)mm

XC-0356 ***Was $59.95***

$39.95 SAVE $20

USB 2.0 DVD Maker II

Turn your aging collection of VHS video tapes into new video productions or record video straight to your DVD or CD burner. Works on PC or MAC® and the included software allows editing/publishing for web applications etc.

- Composite Video input via RCA connector or S-Video mini-DIN
- Windows compatible
- Size: 35(W) x 95(D) x 15(H)mm

XC-4867 ***Was $69.95***

$59.95 SAVE $10

Wi-Fi Remote IP Camera

The smallest IP camera we've ever seen! With its wireless network interface, the camera allows you to stream and record audio video images over your network or directly to your Smartphone (Phones® or Android™ devices) and laptop on the go.

- 640 x 480 resolution
- Size: 30(Dia.)mm

QC-3368

Cradle & Adaptop available separately QC-3369 ***$29.95***

$99.95

Gaming Backphones with Built-in Bass Shakers

These backphones have a built-in bass shaker that adds depth and realism to your gaming experience. Include a concealed microphone perfect for network games.

- Lightweight with soft padded earpieces

XC-4969 ***Was $49.95***

$19.95 SAVE $30

In-Car Laptop Power Supplies

Keep you laptop or netbook charged on the road. Models to suit most of the mini computers on the market. Check our website for compatibility.

50W Automatic MP-3479 ***$34.95***
90W Automatic MP-3324 ***$59.95***
150W Manual MP-3472 ***$74.95***

From **$34.95**

Convert Slides, Film & Photos to Digital

Easy DIY way of digitally archiving, sharing and saving cherished photos.

USB Slide/Film Scanner

Scan directly to your PC using the provided software.

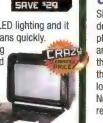
- 1,800dpi resolution
- Windows compatible
- Size: 85(W) x 165(H) x 90(D)mm

XC-4881 ***Was $74.00***

$45.00 SAVE $29

USB Photo Scanner

Features an 8MP sensor and white LED lighting and it will produce clear high resolution scans quickly. Enables you to do basic photo editing such as crop, straighten, retouch and colour adjust. See website for full specs and system requirements.



- Four photo sizes: 3.5 x 3.5, 3.5 x 4.5, 3.5 x 5.0, 4.0 x 6.0 inches
- PC & MAC® compatible
- USB 2.0

XC-4910 ***Was $129.00***

$69.00 SAVE $60

USB Combo Image Scanner with LCD

Connect this to your PC and take high resolution scans of all your photos, slides and negatives to preserve in JPEG or TIF format.

- 2.4" LCD
- Size: 210(L) x 230(W) x 150(H)mm

XC-4893 ***Was $199.00***

$129.00 SAVE $70

Powered USB Extension Lead with 4-Port Hub

Extend your printer or any other USB device as far as 10 metres away from your PC. A 4-port hub adds extra flexibility.

- Powered by USB from the host computer

XC-4122 ***Was $49.95***

$19.95 SAVE $30

USB Device Share Hub

Share a printer, external drive or any other USB device between two computers. Each computer plugs into the hub via USB cable and you switch between them using the switch on the unit or via the scroll lock key on your keyboard. No power, drivers or software required. PC or MAC®.

- USB-B cable required for each computer
- Size: 100(L) x 80(W) x 27(D)mm

XC-4944 ***Was $24.95***

$14.95 SAVE $10

Tiny 300k Notebook USB Webcam

Excellent for on-the-go online video conferencing or chatting. It has a built-in microphone to keep set-up to a minimum. Mounts on top of a thin LCD laptop screen.

- Plug and play
- Size: 28(W) x 59(H x14(D)mm

QC-3231 ***Was $19.95***

$14.95 SAVE $5

Right Angle Computer Adaptors

DB9 Male to DB9 Female Adaptor
PA-0908 ***$5.95***

DB15HD Male to DB15HD Female Adaptor
PA-0909 ***$5.95***

NEW **$5.95**

USB to Apple® Connector/USB Micro B and Mini B Cable

A versatile USB cable that can connect to an Apple® iDevice, or anything that features a micro or mini USB socket. The t-shaped end of the cable features a USB mini and micro plug on either side as well as an Apple® connector that can piggy back off the micro USB plug.

- Cable length: 1.1m (approx)

WC-7691

NEW **$19.95**

Remote PC Control Over Ethernet Adaptor 1080p

Want to play games, browse the net or watch films on your TV when your computer is in another room? This adaptor allows all of the above over a simple Ethernet connection. It features 2 x USB ports to connect a keyboard/mouse for remotely controlling your PC and 2 x 3.5mm sockets for audio and microphone input. Output is to DVI which may require an adaptor for connection to your flat panel TV. See website for more details.

- Windows compatible
- Size: 120(L) x 57(W) x 21(H)mm

XC-4976 ***Was $129.00***

$99.00 SAVE $30

Jaycar — Better. More Technical.

CARAVAN LIGHTING & ACCESSORIES

Rechargeable Halogen Spotlight

Provides 20 minutes continuous operation with 3,000,000 candlepower will be plenty of light for any outdoor activity. Rechargeable and ruggedly built.

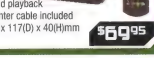
- Built-in SLA battery
- Locking on/off switch
- High impact rubber lens protector
- LED map light
- AC and DC chargers included
- Size: 210(L) x 150(Dia.)mm

ST-3301 ***Was $29.95***

$19.95 SAVE $10

12VDC HD Digital Set Top Box

Great for use on the road, this high definition set top box will pickup all the digital channels on offer in the area. You can also plug in a USB drive and record TV in MPEG2 format to watch at a later date.



- Output: HDMI, Composite, RF
- USB port for recording and playback
- Cigarette lighter cable included
- Size:154(W) x 117(D) x 40(H)mm

XC-4921

$69.95

IP67 Waterproof LED Flexible Strip Light

A 1m long fully waterproof, flexible LED strip light that is perfect for any outdoor application needing reliable lighting. Uses 60 of the highest brightness 5060-SMD type LEDs that are fully sheathed in a protective plastic casing to protect from water, dust and damage. See website for full specifications.

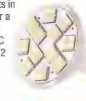
- Powered by 12VDC
- Size: 1000(L) x 10(W)mm

ZD-0579

$49.95

MR11 LED Downlights 120º

Great for use as reading lights in caravans but also suitable for a variety of other applications. Easily powered from a 12VDC (or AC) power source. Uses 12 x 5050 SMD LEDs.



- 130 lumens
- Size: 34(Dia.) x 29(D)mm

Cool White ZD-0562 ***$14.95***

Warm White ZD-0563 ***$14.95***

NEW **$14.95**

5W 80 Channel UHF Transceiver

Amazing range and clarity suitable for long distance communication. Switch to power saving 1W output for short distance communication. Includes Li-ion rechargeable battery pack, AC adaptor, charging cradle and belt clip.

- 80 channels with CTCSS
- Channel scan, dual watch, key lock, VOX, auto power save and repeater functions
- Antenna: 165mm long
- Size (without antenna): 130(L) x 60(W) x 35(D)mm

DC-1065

$149.00

Solar Powered Ventilator

Completely solar powered to reduce mould, mildew, moisture and excess heat build-up in boats, caravans and RVs, or anywhere else you need air extraction. Cut-out size: 150mm.

- Wall or roof mounting
- Stainless shroud
- Gasket included
- Size: 215(Dia.) x 30(H)mm

MP-4559 ***Was $79.95***

$64.95 SAVE $15.00

19 LED Caravan & Automotive Roof Light

Provide more illumination in your car or caravan with this 12VDC LED powered rooflight that makes use of 19 x white high brightness LEDs. Easy to install and operate.

- Size: 147(Dia.) x 36(H)mm

SL-3446

NEW **$34.95**

24 LED Caravan Roof Light

For a reliable light source in your caravan that won't blow like incadescent globes, this 12VDC powered light uses an array of 24 high brightness white LEDs that will light up your interior.

- Size: 213(L) x 66(W) x 41.5(H)mm

SL-3447

NEW **$44.95**

MR16 LED Downlights 120º

MR16 replacement downlights for your caravan or mobile home. Utilise 24 x 5050 SMD LEDs that will output up to 300 lumens of warm white or cool white light.

- 300 Lumens
- Input power: 12VAC/DC
- Size: 50(Dia.)mm x 46(H)mm

Warm White ZD-0561 ***$19.95***

Cool White ZD-0560 ***$19.95***

NEW **$19.95**

LED REPLACEMENT LAMPS

G4 LED Replacement Lights

Great for use as a low wattage replacement globe in desk lamps, rangehoods, and other household applications. Features a 120 degree light angle for a broad spread of light.

- 120 Lumens
- Size: 27(Dia.)mm

Cool White ZD-0568 ***$13.95***

Warm White ZD-0569 ***$13.95***

NEW **$13.95**

GU10 3W CREE® LED Downlight

Each uses one CREE® XR-E LED driven at 3W.

- Colour: White
- GU10 base
- 160 lumens
- Mains powered
- Size: 50 x 55mm

ZD-0362 ***Was $34.95***

CRAZY LOW PRICE

$14.95 SAVE $20

MR16 LED Downlight

Utilises three 1W Nichia 083B LEDs to produce an amazing amount of light. Perfect as a drop-in replacement for MR16 halogen downlights, retail display lights or remote solar/wind/battery power systems.

- LED life: 40,000 hours
- 250 lumens
- Size: 50(Dia.) x 40(D)mm

ZD-0358 ***Was $59.95***

CRAZY LOW PRICE

$29.95 SAVE $30

LED MR16 Replacement Lamp

LED illumination lamps have significant advantages over incandescent lamps. They are long lasting, have lower heat generation and low power consumption.

- Colour: white
- 1.5 to 2W
- GU5.3 base
- 20 LEDs per unit

ZD-0320 ***Was $29.95***

CRAZY LOW PRICE

$9.95 SAVE $20

CREE® LED Downlight Kits

Featuring CREE® XR-E LEDs with 110 to 400 lumens, these offer comparable light to a 50W halogen downlight but at just 10% the power consumption! Life expectancy is over 50,000 hours. Power supply included.

1 x CREE® LED Downlight Kit

- 110 - 130 lumens
- Size: 60 x 45mm (45mm cutout)

ZD-0370 ***Was $49.95***

Now $29.95 Save $20

4 x CREE® LED Downlight Kit

- 400 - 450 lumens
- Size: 90 x 110mm (77mm cutout)

ZD-0372 ***Was $129.00***

Now $49.00 Save $80.00

Limited stock. Not available online.

CRAZY LOW PRICE

From **$29.95** SAVE $20

E14 CREE® LED Downlight

Drop-in replacements for E14 fittings.

- Colour: White
- Power: 3.3W
- Brightness: 110 - 130 lm
- Input voltage: 100 - 240VAC
- Size: 50 x 73mm

ZD-0366 ***Was $39.95***

CRAZY LOW PRICE

$24.95 SAVE $15

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/06/2012.

SECURITY & SURVEILLANCE

Universal Fingerprint Access Controller

A complete bio access control solution that enables you to enrol up to 120 users. The fingerprint scanner reads in less than two seconds. It has a robust cast housing and all operating parameters are stored in a flash memory so it won't be lost due to power failure.

- All metal construction
- Weatherproof and tamperproof
- IR remote control
- Up to 4 supervisors
- 12VDC powered
- Size: 68(W) x 115(H) x 32(D)mm

LA-5122 ***Was $299.00***

$149.00 SAVE $150

Low Cost RFID Access Control Keypad

This low cost RFID unit is designed to control door strikes in home or business access control installations. It allows 4 entry methods: password, proximity card, password + proximity card and egress push button entry.

- 12VDC powered

LA-5124 ***Was $79.95***

RFID tags to suit:

Key Fob Type	ZZ-8950	*$12.95*
Credit Card Type	ZZ-8952	*$6.95*
Lanyard Type	ZZ-8953	*$4.95*

$29.95 SAVE $50

Limited stock. Not available online.

Biometric Finger Scan Safe

This advanced biometric safe provides secure storage using a finger print scan for fast and simple access in just 2 seconds! Features a built-in flash memory retaining the fingerprint data even during a battery failure. Ideal for storing money, passports, jewellery or other personal documents. Complete with 2 back up keys and a 1m alloy security cable for attaching to your bed frame or placing it in your closet. Mounting hardware included

- Requires 4 x AA Alkaline batteries
- Size: 273(L) x 190(W) x 51(H)mm

HB-5457

NEW **$149.00**

2.4GHz Baby Monitor System with Portable LCD & Night Vision

Monitor your baby sleeping or your kids at play in the backyard. Features a portable 2.4" colour LCD and CMOS colour camera with inbuilt mic. The 2.4GHz digital transmission ensures a stable, clear and interference free picture up to 100m away. The camera unit features infrared night vision and voice activation mode to keep you alert throughout the night.

- Rechargeable Li-ion battery and charging cradle for monitor included
- 4 channel operation

QC-3251 ***Was $169.00***

$129.00 SAVE $40

Network Connect Vandal Proof Mini Dome Camera

Designed to take advantage of power over Ethernet to reduce installation costs and setup time, connect straight to your existing network for complete control. Access the camera through a web interface by hitting the IP address of the device and logging in. The web interface allows you to control the camera around 3-axis, zoom, adjust visual settings, record, take snapshots and setup scheduled recording.

- Compression H.264/MPEG4/JPEG
- Sensor: 1/4 inch CMOS
- Resolution: 640(H) x 460(V)
- Size: 99(W) x 97(L) x 45(H)mm

QC-8624 ***Was $259.00***

$199.00 SAVE $60

8 Zone Wireless Alarm Kit

Secure your house, apartment or business without running cables. The system "learns" what sensors are connected and the part arm function allows you to protect certain zones while others are disarmed. Easy to install, ideal for rented or temporary premises.

- Kit includes siren, keypad, PIR sensor, reed switch and power supply

LA-5150 ***Was $199.00***

Additional sensors and accessories available separately, see in-store or online for more info.

$169.00 SAVE $30

Wireless Colour Video Doorphone

A compact wireless video doorphone that's full on features. Incorporating digital encryption and code-hopping 2.4GHz wireless transmission, signals are clear and interference-free up to 100m range. The receiver unit features 3.5" TFT LCD, stores up to 200 images and a built-in rechargeable battery. The camera unit is equipped with a wide angle lens IR illumination and is easy to install.

- Clear night vision
- Mini USB for PC interface
- Rechargeable lithium battery
- Size: 290(W) x 210(H) x 50(D)mm

QC-3253 ***Was $299.00***

$229.00 SAVE $70

2.5" LCD Electronic Door Peep Hole Viewer

With its 2.5" LCD screen and a built-in distortion compensation feature, you can see the person clearly on the other side of the door by a simple press of a button. The camera is no bigger than an original fisheye viewer and looks the same as a peep hole viewer from the outside. Simple to install without compromising door security. Comes complete with an installation tool and AA batteries.

- Size: 146(W) x 90(H) x 30(D)mm

QC-3267 ***Was $199.00***

$129.00 SAVE $70

RF Bug Detector

Make sure your private conversations stay private with this mini RF bug detector. Detects transmissions between 50MHz & 6,000MHz (6GHz). The unit can be operated in silent mode with the built-in vibrator & features an RF sensitivity control, a 'battery low' warning light and handy belt clip.

- Size: 55(W) x 92(H) x 25(D)mm

QC-3430 ***Was $149.00***

$99.00 SAVE $50

Dual Beam Infrared Barrier

Protect your doors or windows with this dual beam infrared detector. Housed in a strong aluminum and suitable for outdoor environments (IP55). The detector will sound an internal buzzer and energise a relay when the beam is broken or tampering is detected.

- Mounting hardware included
- Length 570mm

LA-5186 ***Was $169.00***

$99.00 SAVE $70

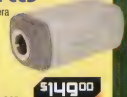
Professional CCD Cameras

Range of professional CCD cameras below with great prices.

- 752 x 582 resolution
- 550 TV Lines
- Power: 24VAC/12VDC

Day / Night Colour CCD

High resolution day/night camera with Sony® sensor, colour by day, black and white by night. Extremely high performance in low light levels. Perfect for use with infrared illuminators.



- Flickerless
- 1/3" Sony Hi-Res Super HAD CCD

QC-8621 ***Was $199.00***

$149.00 SAVE $50

High Resolution ExView Colour CCD - Pro Style

Ideal for use with infrared illuminators and features high speed electronic shutter, back light compensation and 3 stage automatic gain control.

- 1/3" Sony Hi-Res ExView HAD CCD
- Size: 145(L) x 68(W) x 57(H)mm

QC-8622 ***Was $249.00***

$199.00 SAVE $50

Wide Dynamic Range CCD

Professional grade camera based around Sony's SS2 vertical double-density wide dynamic range CCD system. Provides a high quality picture.

- 1/3" Sony CCD
- Size: 145(L) x 68(W) x 57(H)mm

QC-8623 ***Was $399.00***

$199.00 SAVE $200

NO. 1 FOR KITS

Mixture Display Kit For Fuel Injected Cars

Thousand's SOLD!

Refer: Silicon Chip November 1995

This very simple kit will allow you to monitor the fuel mixtures being run by your car. This type of sensor is also known as an E.G.O. (exhaust, gas, oxygen) monitor. The circuit connects to the EGO sensor mounted in the exhaust manifold and the cars battery. PCB, LEDs and components supplied.

- PCB: 74 x 36mm

KC-5195

$16.95

Salt Water Fuel Cell Engine Car Kit

An educational kit demonstrating the concept of a salt powered automotive engine. It gives the next generation a look at alternative means of propelling cars of the future. Assemble, add salt water, and your 4WD car will be propelled forward.

- Assembly time: 3 hours
- Recommended for ages 8+

KJ-8960

Kit for kids

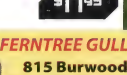
NEW

$24.95

Car Battery Monitor Kit

Refer: Electronics Australia May 1987

This simple electronic voltmeter lets you monitor the condition of your car's battery so you can act before getting stranded. 10 rectangular LEDs tell you your battery's condition. Kit includes PC board and all components.



- PCB: 62 x 39mm

KA-1683

$17.95

G-Force Meter Kit

Measure the g-forces on your vehicle and it's occupants during your next lap around the race circuit, or use this kit to encourage smoother driving to save petrol and reduce wear & tear. Forces (+/- 2g) are displayed on the 4-digit LED display. Also use it to measure g-forces on a boat crashing over waves or on a theme park thrill ride. Kit includes PCB with pre-mounted SMD component, pre-programmed microcontroller and all onboard electronic components.

- Requires 2 x AA batteries
- PCB: 100(L) x 44(W)mm

KC-5504

NOTE: We supply the PCB with the SMD component already mounted on the board to save time and frustration.

Limited stock. Not available online.

$49.95

Programmable High Energy Ignition Kit for Cars

Refer: Silicon Chip Magazine March 2007

This advanced and versatile ignition system can be used on both two & four stroke engines. The system can be used to modify the factory timing or as the basis for a stand-alone ignition system with variable ignition timing, electronic coil control and anti-knock sensing. Kit includes PCB with overlay, programmed micro, all electronic components, and die cast box.

- Suitable for single coil systems
- Dwell adjustment
- Single or dual mapping ranges
- Max & min RPM adjustment
- PCB: 102 x 81mm

KC-5442

$69.95

High Range Adjustable Temperature Switch for Cars

Refer: Performance Electronics for Cars - Silicon Chip Publications

This temperature switch can be set anywhere up to 1200°C. The relay can be used to trigger an extra thermo fan on an intercooler or a simple alarm to warn you of overheating. The LCD which can easily be dash mounted, displays the temperature constantly. Kit supplied with solder masked PCB with overlay, LCD panel, temperature probe and all electronic components.

- PCB: 105 x 60mm

KC-5376

$72.95

Party Lighting Kits

DMX Controller USB Interface

This kit controls DMX fixtures such as spotlights using a PC and USB interface. It can also be operated in stand-alone mode that outputs all 512 channels at the same time (9V battery required for stand-alone mode). Includes software, USB cable and enclosure.

- Test software and DMX Light Player software included
- 512 DMX channels with 256 levels each
- 3 pin XLR-DMX output connector

CRAZY PRICE!

KC-3610 *Was $149.00*

$99.00

SAVE $50

DMX Relay Control Kit

Control a relay with the DMX512 protocol. The relay will be activated when the DMX value of the set channel equals 140 or more and turns off when the value is 120 or less. Team it with KV-3610 to make a computer-controlled automation system. Short form kit.

- 512 unique addresses, DIP switch settable
- Relay hold function in case of DMX signal loss

CRAZY PRICE!

KV-3612 *Was $49.95*

$29.95

SAVE $20

DMX Control Dimmer Kit

Allows you to control a lamp or group of lamps through a DMX signal. You can use the USB Controlled DMX Interface kit or any other control console compliant with the DMX-512 protocol as a controller. It will drive resistive loads like incandescent lamps and mains voltage halogen lighting. Shortform kit.

- 512 unique addresses, selectable with DIP switch
- Status LED for power and error detection
- Stand alone mode for testing

KV-3614 *Was $79.95*

CRAZY PRICE!

$49.95

SAVE $30

NEW STORE - FERNTREE GULLY

815 Burwood Highway VIC 3156

Ph. (03) 9758-0141

Parking available

YOUR LOCAL JAYCAR STORE - Free Call Orders: 1800 022 888

• AUSTRALIAN CAPITAL TERRITORY

Belconnen Ph: (02) 6253 0700
Fyshwick Ph: (02) 6239 1801

• NEW SOUTH WALES

Albury Ph: (02) 6021 6788
Alexandria Ph: (02) 9699 4699
Bankstown Ph: (02) 9709 2822
Blacktown Ph: (02) 9678 9669
Bondi Junction Ph: (02) 9369 3899
Brookvale Ph: (02) 9905 4130
Campbelltown Ph: (02) 4620 7155
Castle Hill Ph: (02) 9634 4470
Coffs Harbour Ph: (02) 6651 5238
Croydon Ph: (02) 9799 0402
Erina Ph: (02) 4365 3433
Gore Hill Ph: (02) 9439 4799
Hornsby Ph: (02) 9476 6221
Liverpool Ph: (02) 9821 3100
Maitland Ph: (02) 4934 4911
Newcastle Ph: (02) 4965 3799
Penrith Ph: (02) 4721 8337
Port Macquarie Ph: (02) 6581 4476
Rydalmere Ph: (02) 8832 3120
Sydney City Ph: (02) 9267 1614
Taren Point Ph: (02) 9531 7033
Tuggerah **NEW** Ph: (02) 4353 5016
Tweed Heads Ph: (07) 5524 6566
Wagga Wagga Ph: (02) 6921 9333
Wollongong Ph: (02) 4226 7089

• NORTHERN TERRITORY

Darwin Ph: (08) 8948 4043

• QUEENSLAND

Aspley Ph: (07) 3863 0099
Caboolture Ph: (07) 5432 3152
Cairns Ph: (07) 4041 6747
Capalaba Ph: (07) 3245 2014
Ipswich Ph: (07) 3282 5800
Labrador Ph: (07) 5537 4295
Mackay Ph: (07) 4953 0611
Maroochydore Ph: (07) 5479 3511
Mermaid Beach Ph: (07) 5526 6722
Nth Rockhampton Ph: (07) 4926 4155
Townsville Ph: (07) 4772 5022
Underwood Ph: (07) 3841 4888
Woolloongabba Ph: (07) 3393 0777

• SOUTH AUSTRALIA

Adelaide Ph: (08) 8231 7355
Clovelly Park Ph: (08) 8276 6901
Gepps Cross Ph: (08) 8262 3200
Reynella Ph: (08) 8387 3847

• TASMANIA

Hobart Ph: (03) 6272 9955
Launceston Ph: (03) 6334 2777

• VICTORIA

Cheltenham Ph: (03) 9585 5011
Coburg Ph: (03) 9384 1811
FernTree Gully **NEW** Ph: (03) 9758 0141
Frankston Ph: (03) 9781 4100
Geelong Ph: (03) 5221 5800
Hallam Ph: (03) 9796 4577
Kew East Ph: (03) 9859 6188
Melbourne Ph: (03) 9663 2030
Ringwood Ph: (03) 9870 9053
Shepparton Ph: (03) 5822 4037
Springvale Ph: (03) 9547 1022
Sunshine Ph: (03) 9310 9066
Thomastown Ph: (03) 9465 3333
Werribee Ph: (03) 9741 8951

• WESTERN AUSTRALIA

Joondalup Ph: (08) 9301 0916
Maddington Ph: (08) 9493 4300
Mandurah Ph: (08) 9586 3827
Midland Ph: (08) 9250 8200
Nonbridge Ph: (08) 9328 8252
Rockingham Ph: (08) 9592 8000

Arrival dates of new products in this flyer were confirmed at the time of print. Occasionally these dates change unexpectedly. Please ring your local store to check stock details. **Prices valid from 24th May to 23rd June 2012.**

HEAD OFFICE
320 Victoria Road, Rydalmere NSW 2116
Ph: (02) 8832 3100 Fax: (02) 8832 3169

ONLINE ORDERS
Website: www.jaycar.com.au
Email: techstore@jaycar.com.au

Jaycar Electronics
Better, More Technical

PRODUCT SHOWCASE

Universal Charger for Cordless Power Tools (4.8-24V)

Have a cordless power tool and can't find the charger? If it has a Ni-MH or Ni-Cd battery then this charger will solve your problem.

It features intelligent polarity operation, which automatically detects the polarity and voltage of your battery and charges it accordingly. Operating from 12V DC (cigar lighter plug included) or 100-240V AC via power adaptor (also included), you simply connect the strong magnetic or alligator clip connectors to your battery and this smart charger will do the rest. It incorporates two status LEDs, one indicating that the battery is charging and the other indicates once it is full. Charging time is 1-3 hours depending on battery capacity.

Recommended retail price is $79.95 (Cat no MB-3631), it's available from Jaycar stores, resellers or via the Jaycar web store.

Contact:
Jaycar Electronics (all stores)
PO Box 107, Rydalmere NSW 2116
Order Tel: 1800 022 888 **Fax:** (02) 8832 3188
Website: www.jaycar.com.au

New world record for efficiency in organic solar cells

Heliatek GmbH, a German company which specialises in the design and production of solar cells, has just achieved an efficiency of 10.7% for its latest organic photovoltaic (OPV) cells.

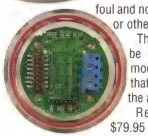
Heliatek is the only solar company in the world that uses the deposition of small organic molecules in a low temperature, roll-to-roll vacuum process. Their solar tandem cells are made of nanometer thin layers of high purity and uniformity. They can literally engineer the cell architecture to systematically improve efficiency and lifetime.

The measurement results for low light established that the efficiency not only remains constant but even increases gradually. At an irradiation of 100W/m² the efficiency is 15% higher compared to the standard efficiency measured at 1,000 W/m².

Ocean Controls' Rain Gauge uses infrared light

The RG-11 Rain Gauge senses water hitting its outside surface using beams of infrared light.It uses the same sensing principle used in millions of automotive rain sensing windshield wiper controls.

Because it is optical – not mechanical, chemical, or conductive – it is far more rugged, sensitive and reliable than any other technology. The sensor is extremely sensitive and virtually immune to false trips. Yet it is completely unaffected by jostling and motion. There are no exposed conductors to corrode, no tipping buckets to foul and no openings for bugs to crawl into. There is no place for leaves or other debris to collect.

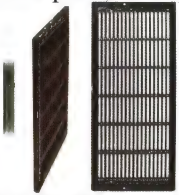


The RG-11 Rain Sensor includes a DIP switch that allows it to be set up for the mode of operation that best matches the application.

Retail price is $79.95 +GST.

Contact:
Ocean Controls
PO Box 2191, Seaford BC, Vic, 3198
Tel: (03) 9782 5882 **Fax:** (03) 9782 5517
Website: www.oceancontrols.com.au

New RTA electrostatic speaker panels



Reality Technologies Australia's (RTA) new UFPS-440 Electrostatic Loudspeaker panel measures 168mm across by 440mm high, at only 8mm thick, making it ideal for use in companion speakers to or for integration into the latest generation of flat panel television screens.

RTA's several decades of speaker engineering expertise behind the technology has enabled them to create a flat panel speaker that also has high quality audio reproduction, overcoming a traditional barrier with other flat panel technology. Traditional problems with electrostatic speaker panels have also been overcome.

RTA is now able to supply high quality, low cost panels, reproducible in high volumes for OEM purposes, without the need for expensive high-current amplifier circuitry to drive it. Furthermore, the technology can be employed to create custom shapes and sizes for integration into new or existing product lines.

The UFPS-440 speaker panels are also available in kit form, including two panels and all associated electronics.

More detailed specifications and test data are available at the company's website. *sc*

Contact:
Reality Technologies Australia
33 Malcolm Rd, Braeside, Vic 3195
Tel: (03) 8581-7638 **Fax:** (03) 9587-4986
Website: www.reality-design.com.au

Anyone can build this high performance four-channel audio mixer. . .

Want to mix two or more audio signals together? Maybe it's an MP3 player and a microphone so you can "play" Karaoke. Or perhaps you've formed the next earth-shattering band and need to mix a couple of guitars and a mic or two together. Or you've built a PA amplifier and want to be able to drive it from a variety of signal sources. Here's the answer: this 4-channel mixer might be simple and cheap to build – but its performance lacks for nothing!

By Nicholas Vinen

Mix-It!

This mixer is something of a reprise of two very popular 4-Channel Guitar Mixers featured in SILICON CHIP – the first in our January 1992 issue and a more recent version in June 2007.

While this one has several similar features, (it is an audio mixer, after all!) it also has a number of improvements – for example, performance, cost, easy to build – and as a bonus, the PCB is actually smaller than either so you can fit it into a smaller case.

It features four inputs which can be configured for a wide variety of signal sources, from very low level (eg, microphone or guitar) right through to quite high (eg iPODs/MP3 players, CD/cassette decks [Gad, what are they?]) and the like.

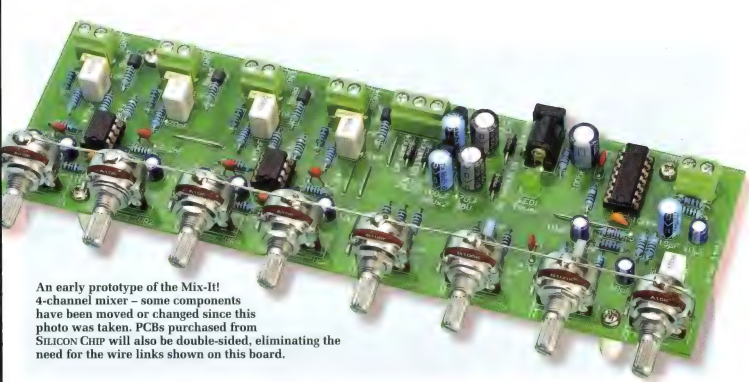
It has bass, midrange and treble controls, individual channel level controls along with a master volume control and an on-board power supply. You can build it as a stand-alone unit or incorporate it into a PA or guitar amplifier.

In fact, it doesn't even need to be a PA/guitar amplifier: with almost 800mV output, this mixer could be used with virtually any amplifier with a "line in" or similar input.

Other features include a variety of power supplies – it could use a low voltage AC supply – say

Features

- Four unbalanced inputs with 1MΩ || 100pF input impedance (see text)
- Gain of 0-36dB per channel (depending on feedback components)
- Bass, mid and treble controls (±10dB)
- Master volume control
- Input radio signal filtering
- Flat frequency response
- Low distortion and noise
- Four supply options: 15VAC, 12-30V DC, ±15V or unregulated split supply



An early prototype of the Mix-It! 4-channel mixer – some components have been moved or changed since this photo was taken. PCBs purchased from SILICON CHIP will also be double-sided, eliminating the need for the wire links shown on this board.

around 15V – or it could use a split DC supply such as that commonly found in amplifiers (eg, ±15V).

We'll have more to say on the supply shortly.

How it works

Each of the four identical inputs, CON1-CON4, can be fitted with either a terminal block or preferably, a PCB-mounting shorting-type RCA socket. We say preferably because unconnected inputs are then shorted to ground and therefore don't introduce any noise or hum into the circuit.

Each input has an RF filter, consisting of a ferrite bead and 100Ω resistor in series with the signal and a 100pF capacitor to ground. These act as low-pass filters with a cutoff frequency of 16MHz while the ferrite beads greatly improve the rejection of signals above a couple of hundred kilohertz.

We mentioned "ground" a moment ago. In this circuit, it's important to note that there are two different "grounds". The first is the "power" ground and uses the conventional ground symbol (⏚). The second is the "signal" ground and uses a different symbol (⏚). We'll explain these a bit more when we look at power supplies shortly.

The audio signals are then AC-coupled to op amps IC1b, IC1a, IC2b and IC2a via 470nF capacitors with 1MΩ biasing resistors. This high value is necessary if the mixer is used with electric guitars, as their frequency response changes when driving lower impedances due to loading effects on the inductive pick-up(s). The relatively low value RF filtering capacitors (100pF) were chosen for the same reason.

While most of the coupling capacitors in the circuit have been increased compared to the original designs, here we have used a lower value since the input coupling capacitors need to be non-polarised. This is because the signal source could potentially have a high DC bias or the input might be accidentally shorted to a power rail.

We also wanted to use an "MKT" (polyester) capacitor as they are more reliable and linear than non-polarised electrolytics, which also vary greatly in size.

Before each op amp is a 100Ω resistor, which acts as an additional RF stopper.

IC1a-IC2b are TL072 low-noise JFET input op amps. Due to the high value bias resistors, the LM833s used in the original design are not suitable. They would have an excessive output DC offset due to their relatively high input bias currents. JFET input op amps have a much lower input bias current with only a small increase in noise.

The gain for these op amps is set by the two resistors at their outputs. In the circuit we have used "middle of the road" values of 1.8kΩ and 220Ω, resulting in a gain of about 9.2x (18dB). Gain is calculated using the formula

$$\frac{1.8k\Omega + 220\Omega}{220\Omega}$$

This is about half that of the original design, which could not handle line-level input signals without clipping. This one can – up to 900mV RMS or more with reduced gain.

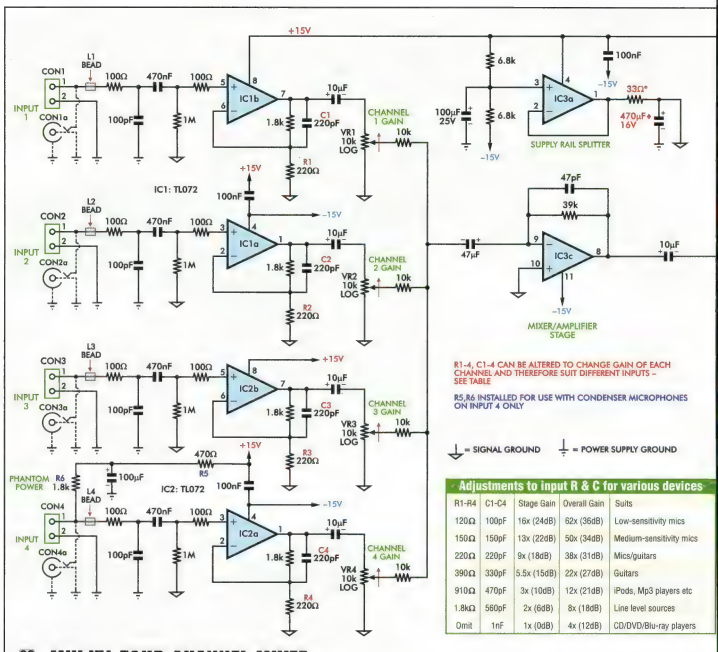
These values can be changed to suit various input devices, as we shall see shortly.

The feedback capacitors (nominated as 220pF) roll off the op amp closed-loop gain at high frequencies to improve stability, reduce noise and provide a further degree of RF rejection.

The op amp outputs are AC-coupled via 10µF electrolytic capacitors to 10kΩ log volume pots (VR1-VR4). These capacitors are polarised, to minimise size and cost. We can get away with it because the op amp input bias currents (small though they may be with JFET inputs) cause the op amp out-

Specifications

- Input range for line level output: 18-900mV
- Frequency response: 20Hz-20kHz, +0,-1.2dB (see Fig.3)
- Signal-to-noise ratio: -75dB @ 32dB gain; -92dB @ 0dB gain
- THD+N (for 20Hz-20kHz bandwidth): 0.015% @ 32dB gain; 0.003% @ 18dB gain; 0.002% @ 0dB gain)



Adjustments to input R & C for various devices

R1-R4	C1-C4	Stage Gain	Overall Gain	Suits
120Ω	100pF	16x (24dB)	62x (36dB)	Low-sensitivity mics
150Ω	150pF	13x (22dB)	50x (34dB)	Medium-sensitivity mics
220Ω	220pF	9x (18dB)	38x (31dB)	Mics/guitars
390Ω	330pF	5.5x (15dB)	22x (27dB)	Guitars
910Ω	470pF	3x (10dB)	12x (21dB)	iPods, Mp3 players etc
1.8kΩ	560pF	2x (6dB)	8x (18dB)	Line level sources
Omit	1nF	1x (0dB)	4x (12dB)	CD/DVD/Blu-ray players

Fig.1: the circuit diagram consists of four near-identical input stages, the outputs of which are mixed and amplified before being fed into a tone control stage and output buffer. Any of the four inputs may be altered from that shown to account for different audio devices – anything from a microphone to a Blu-ray player can be accommodated (see table above).

puts to have a slightly positive DC bias.

The pot wipers then connect to four 10kΩ mixing resistors which are joined together at the other end. This is the "virtual earth" point and is held at signal ground potential by op amp IC3c.

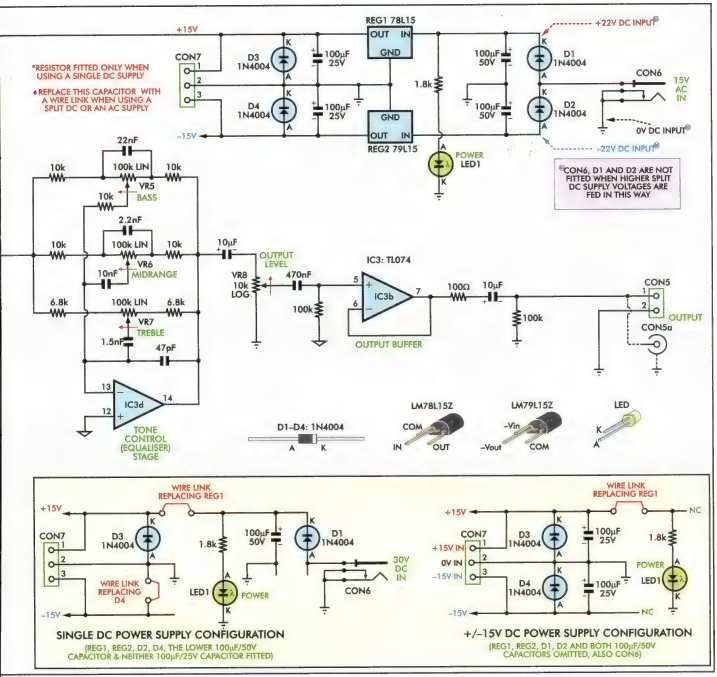
Its non-inverting input (pin 10) is at signal ground potential and it is configured as an inverting amplifier with a gain of -3.9, as set by the ratio of the 39kΩ feedback resistor to the 10kΩ mixer resistors. The overall maximum gain of the unit is therefore 3.9 x 9.2 = 36 or 31dB.

The resulting output signal is the sum of the four input signals (from the wipers of the pots).

A 47pF feedback capacitor limits the bandwidth again and the output is AC-coupled to the active tone control stage with a 10µF capacitor, orientated so that it will have the correct DC bias.

The tone control stage is a traditional Baxandall-style arrangement (named after Peter Baxandall, the man who first described this circuit) with three bands – bass, mid and treble. We have copied this unchanged from the original design as there is nothing wrong with it. Three 100kΩ linear potentiometers, VR5-VR7, adjust the feedback around op amp IC3d which is in an inverting configuration.

The combination of capacitors across VR5 and VR6 with the capacitors at the wipers of VR6 and VR7 mean that each pot controls the feedback over a different audio "band"



Inset at the bottom of the main circuit are two variations for powering the mixer – two are shown on the main circuit diagram above (15V AC and ±22V DC). Each of these is further illustrated on the component overlays on page 63. R5, R6 and the 100µF capacitor on the main circuit are only needed if your microphone requires phantom power (see text).

. Thus they each boost or cut a different range of frequencies. Refer to Fig.9 to see the effect of these pots; this shows the frequency response of the mixer with the controls set at their maximum extents as well as centred (blue trace).

Having been inverted twice, once by the mixer and once by the tone controls, the signal at output pin 14 of IC3d is in-phase with the inputs. This is coupled to the master volume control pot, VR8. The output is taken from the wiper and then coupled with a 470nF MKT capacitor to the non-inverting input of op amp IC3b, with a 100kΩ DC bias resistor. This op amp simply buffers the signal to provide a low-impedance output.

The 100Ω resistor at the output of this op amp isolates it from any cable capacitance which could otherwise cause oscillation. As with the inputs, output connector CON5 is either a terminal block or RCA socket. A final 10µF AC-coupling capacitor is used so that the output DC level is at 0V regardless of the signal ground potential, with a 100kΩ DC bias resistor setting this DC level.

Power supply

Like the original design, this unit can be powered from a ±15V regulated DC supply, via CON7. If the mixer is installed in a case with a preamplifier, there is a good chance that such rails will already be present.

But if not, or in cases where the mixer is used as a stand-alone unit,

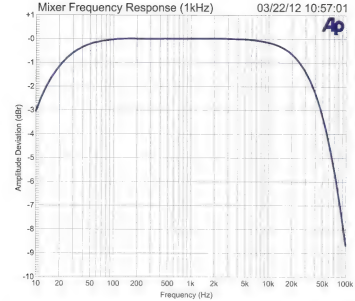


Fig.2: frequency response of the mixer with the tone controls set to their mid positions and gain at maximum. Roll-off is only 1.2dB at 20Hz and -0.75dB at 20kHz while the -3dB points are at 10Hz and 45kHz.

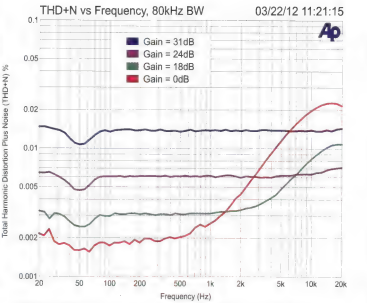


Fig.3: performance with a 15VAC supply. At high gain settings, noise and 50Hz hum field pick-up dominate the distortion graph; the dip at 50Hz is when the test signal cancels some of the mains hum.

the mixer can be run off low voltage AC or DC. An unregulated split supply can also drive the unit in some cases, as will be explained later.

For low voltage AC, 15-16V RMS is supplied to CON6. Diodes D1 and D2 act as two half-wave rectifiers, charging the 100µF 50V capacitors alternately as the AC signal swings positive and negative to provide unregulated rails of approximately ±22V DC. ($(16 \times \sqrt{2}) - 0.6$V).

This is then regulated to ±15V by REG1 (78L15, +15V) and REG2 (79L15, -15V). The output voltages are filtered with 100µF capacitors. Diodes D3 and D4 prevent them from being reverse-biased during operation, which could cause REG1 or REG2 to "latch up" when power is first applied. This can happen because one rail starts to charge up before the other due to the half-wave rectification.

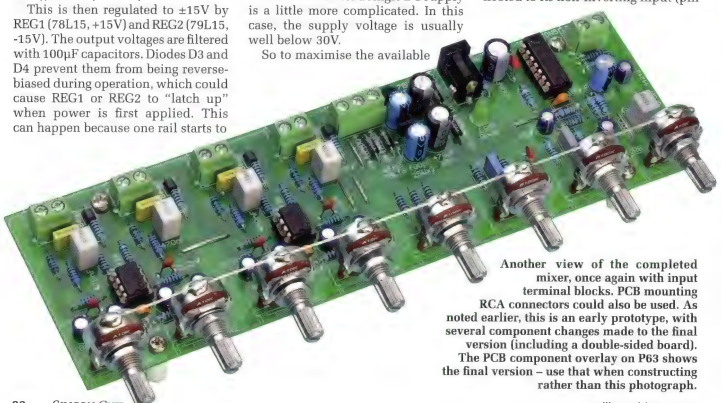
If the unit is to be run from a regulated split supply then this is connected to CON7, bypassing the regulators and powering the circuit directly.

If an unregulated split supply is to be used then it can be connected via the pads for D1 and D2, bypassing the rectifier and feeding the regulators directly.

The situation for a single DC supply is a little more complicated. In this case, the supply voltage is usually well below 30V.

So to maximise the available headroom (the amount by which the signal can be amplified before clipping), the regulators are bypassed (linked out) so that the full voltage, minus D1's forward voltage, is available to the op amps. D2 is also linked out and power is applied via CON7.

In this case, since there is no negative supply, the signal ground potential must be positive. This bias is generated by op amp IC3a. The two resistors connected to its non-inverting input (pin



Another view of the completed mixer, once again with input terminal blocks. PCB mounting RCA connectors could also be used. As noted earlier, this is an early prototype, with several component changes made to the final version (including a double-sided board). The PCB component overlay on P63 shows the final version – use that when constructing rather than this photograph.

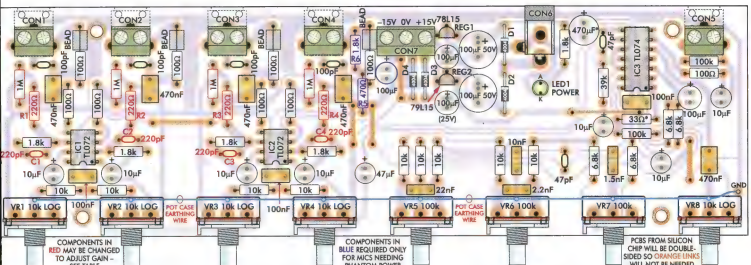


Fig.4: the complete component overlay for the Mix-It! mixer. In this case, we have shown 220Ω resistors and 220pF capacitors in the R1/C1...R4/C4 positions which would make it suitable for guitars and many microphones. However, you can change these resistors to suit other input devices (see the table on the circuit diagram) or even add switching to one or more channels to allow the input(s) to be switched at will (see Fig.8). R5, R6 and the associated 100pF capacitor on input 4 are provided for microphones requiring "phantom power". If you don't need this, you can leave these components out.

3) form a divider across the supply rails, producing a voltage of roughly half the DC supply. For example, if the DC supply is 12V, this point is at about 6V. It is filtered using a 100µF capacitor, to remove supply noise.

IC3a buffers this voltage, providing a low output impedance and this is filtered further using a 33Ω resistor and 470µF capacitor. The 33Ω resistor prevents op amp instability due to the large capacitive load. The RC low-pass filter formed by the 33Ω resistor and 470µF capacitor is important to achieve good performance as even a tiny amount of supply ripple coupling into the signal earth will be greatly amplified and coupled into the output, dramatically reducing the signal-to-noise ratio and increasing the distortion.

We would normally use a 100Ω resistor at the op amp output, to isolate it from a capacitive load but experimentation shows that 33Ω provides better hum rejection, presumably due to the fact that higher values increase the output impedance of the buffer stage too much.

To quantify the loss of headroom when running from a single supply, 12V DC can be considered equivalent to a ±6V split supply. Considering limited op amp voltage swing, this gives a maximum signal handling of about $(6V - 1V)/\sqrt{2} = 3.5V$ RMS. With a fixed gain of 10 at each input, the maximum input level is then 350mV RMS.

That's plenty for most microphones and musical instruments but line level sources are generally at least 500mV and will clip unless they are attenuated somehow (or the input stage gain is reduced; more on that later).

The foregoing explains why separate signal grounds and power supply grounds are required with a single rail DC supply is used. But when an AC or split supply is used, the signal ground is connected directly to power supply ground to ensure the polarised coupling capacitors are correctly biased. This is achieved by omitting the 33Ω resistor and replacing the 470µF capacitor with a wire link.

All these options may seem confusing but we have provided diagrams later showing which components to install in each case.

Construction

The mixer is built on a PCB coded 01106121, 198 x 60mm. Refer to the overlay diagram (Fig.4). If you are not using an AC supply, refer also to one of Figs. 5, 6, 7 or 8 to see the changes required to suit your particular situation.

The PCB will normally be double-sided with plated-through holes, so there will be no need for links. However, we know that some schools like to have students build their projects "from scratch", including making PCBs where possible.

Because it is unlikely students (and some readers!) will make a double-sided board, six tinned copper wire links will be needed for single-sided boards (they're shown on the PCB overlay).

Follow with the resistors. It's best to check the value of each with a digital multimeter before fitting it - you can also use the resistor colour code table as a guide but it's easy to make mistakes (brown for orange for red, for example) so check them twice!

The 1N4004 diodes go in next, with the striped (cathode) ends towards the top of the PCB. If you're using IC sockets, mount them now, with the notches orientated towards the bottom of the PCB, as shown. Otherwise, just solder the ICs into place, taking care that they are orientated with pin 1 towards the bottom of the board. IC sockets do make it easy to place and remove ICs but we prefer to solder them in permanently, as long as there is no mistake!

If installing the regulator(s), bend the leads to fit the pad spacings on the board and solder them in place. Don't get them mixed up and ensure that the flat side faces as shown on the overlay diagram. The LED can be installed next, flat side also facing down, followed by the ceramic and MKT capacitors, from smallest to largest.

Solder 3-way terminal block CON7 in place, with the wire entry holes facing the top edge of the PCB. If you are using terminal blocks for the inputs and outputs, fit them now too. Follow

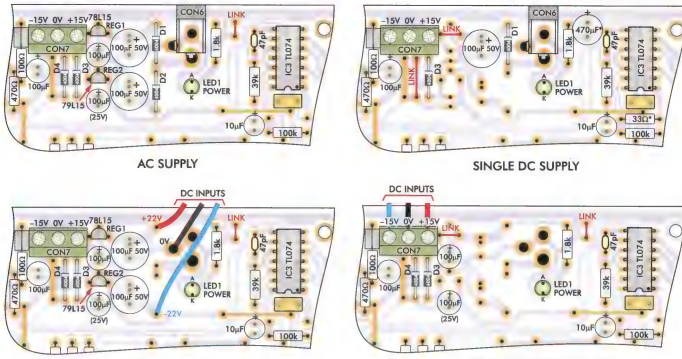


Fig.5: four variations on a theme . . . the mixer is quite versatile as far as power supply goes – simply wire yours according to the power supply you are going to use.

with the DC socket and then the electrolytic capacitors, all of which have the longer positive leads inserted in the hole closest to the top edge of the PCB (stripes towards the bottom edge).

Ensure the correct type of capacitor, as shown on the overlay diagrams, is placed in each location.

If you are using RCA sockets for the inputs and outputs, mount them now, checking that they are pushed down all the way onto the PCB and that the sockets are parallel to the board and perpendicular to the edge.

To minimise noise, all of the pot bodies are connected together and thence to the PCB with a 250mm length of tinned copper wire. To prepare them for soldering, hold gently in a vice and file away a patch of the passivation layer on the top of each pot (otherwise the solder won't take). If your pots have long shafts, now is also a good time to cut them to the length you require (don't forget to take into account any case or cabinet width).

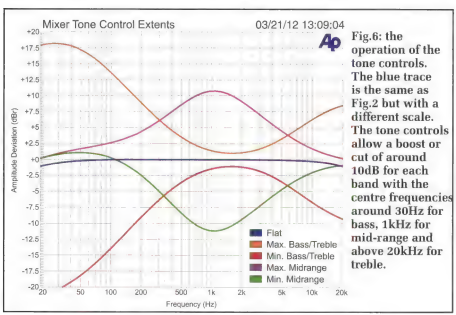


Fig.6: the operation of the tone controls. The blue trace is the same as Fig.2 but with a different scale. The tone controls allow a boost or cut of around 10dB for each band with the centre frequencies around 30Hz for bass, 1kHz for mid-range and above 20kHz for treble.

Solder the pots in place, ensuring that you note the difference between the three 100kΩ linear types and the 10kΩ log types. While you have the soldering iron in your hand, run a thin layer of solder over the surface of the pot where you just removed the passivation.

Now solder one end of the tinned copper wire to the pad marked "GND" to the right of VR8, bend it over the top of VR8 and then solder it to the top of VR1, so that the wire passes across the top of each pot. Once it is held tightly in place, solder it to the top of the remaining pots and trim the excess.

If you are using them, fit the nylon spacers to the four mounting holes and then, if you are using sockets, insert the ICs. They must be orientated with their pin 1 dots at the same end as the notches on the sockets, ie, towards the bottom of the board. If not using sockets, carefully solder in the ICs, again noting orientation.

Housing it

The mixer should ideally be housed in an earthed steel case, although it can be used inside an amplifier or guitar amplifier/speaker case.

If putting it in a case, the pots are all 25.4mm (1 inch) apart so you will need to drill a horizontal row of eight

8mm diameter holes in the front panel. The board can then be "hung" behind the front panel via the potentiometers.

You may need to snap off the small locating spigots on each pot with small pliers (or, preferably, drill small pilot holes to accommodate them. The spigots stop heavy-handed users trying to twist the pots on the panel).

While not really necessary, you can also attach the PCB to the bottom of the case using the tapped spacers – although this method of mounting might be preferable if poking the pot shafts through a thick (eg, guitar speaker box) panel.

The most common input connectors for guitars, microphones and so on will usually be 6.35mm jack sockets and/or XLR sockets. The PCB is designed to accommodate RCA sockets "on board" but this may not be the most convenient to use.

The altenative is to mount the sockets on a case panel – often they are mounted on the front panel or adjacent vertical panel next to their respective controls. If so, you will need to run shielded cable from the sockets to the input connectors (CON1-CON4).

The output can then go to an RCA socket on the rear panel or to an internal power amplifier. Either way, use shielded cable for this connection too.

When using chassis-mount jack sockets, use switched sockets and wire them to short out the input signal when nothing is plugged in, to minimise noise and hum. See Fig.7 for details on how to do this.

The power supply wiring can then be run. Wire split supplies (+15V,0V,-15V) up to CON7. Single DC supplies or low voltage AC go to CON6. The overlay diagrams show how the wires are connected.

If you want a front-panel power indicator, it is possible to mount LED1 off-board and connect it up with flying leads and optionally, a pin header.

Parts list – Mix-It! Four Channel Mixer

1 PCB, code 01106121, 198 x 60mm (*available from Silicon Chip for $20 + P&P*)
5 2-way mini terminal blocks (CON1a-CON5a) OR
5 PCB-mount switched RCA sockets (CON1-CON5)
1 PCB-mount DC socket (CON6)
1 3-way mini terminal block (CON7)
8 small knobs, to suit VR1-VR8
4 small ferrite beads
1 plugpack or other power supply
1 250mm length tinned copper wire (or 400mm if wire links are used)
4 M3 nylon tapped spacers
4 M3 x 6mm machine screws
2 8-pin DIL sockets (optional)
1 14-pin DIL socket (optional)

Semiconductors
2 TL072 dual low noise JFET-input op amps (IC1, IC2)
1 TL074 quad low noise JFET-input op amp (IC3)
1 78L15 +15V 100mA linear regulator (REG1)
1 79L15 -15V 100mA linear regulator (REG2)
1 green 5mm LED (LED1)
4 1N4004 diodes (D1-D4)

Capacitors
1 470µF 16V electrolytic
2 100µF 50V electrolytic
4 100µF 25V electrolytic
1 47µF 50V electrolytic
7 10µF 50V electrolytic
5 470nF MKT
3 100nF MKT
1 22nF MKT
1 2.2nF MKT
1 1.5nF MKT
4 220pF ceramic
4 100pF ceramic
2 47pF ceramic

Resistors (all 1%, 0.25W)

4 1MΩ	2 100kΩ	1 39kΩ	9 10kΩ	4 6.8kΩ
6 1.8kΩ	4 220Ω	9 100Ω	1 33Ω	

5 10kΩ logarithmic 16mm potentiometers (VR1-VR4, VR8)
3 100kΩ linear 16mm potentiometers (VR5-VR7)

Testing

Turn all the volume knobs, including master volume to their minimum (ie, fully anti-clockwise) and set the tone controls to their centre positions. Switch on the power supply and check that LED1 lights.

Plug the output of the mixer into a suitable amplifier and turn that on – with level controls at a minimum you should hear nothing! It's then just a matter of applying a signal to one input, then slowly turning up corresponding input and master volume controls, to check that the output sound is undistorted.

Note that since there is a fair bit of gain available, if you use a line level source, you won't have to turn the volume knobs up very far.

Check each of the four inputs in turn and also check that the tone controls have the appropriate effect on the signal.

If you hear a lot of hum or noise, it's probable that it's being induced into the sensitive input stages from whatever amplifier you've teamed the mixer with – in which case, you might need to house the unit in an earthed metal box inside the amplifier case.

Alternately, hum may be caused by a hum loop, either from the power supply or the input cabling. You might need to experiment a little with earthing arrangements for best results.

Making changes for MP3s etc

Some constructors may wish to experiment with some component values. By doing so, you can adapt it to your particular requirements.

For example, the feedback resistors for IC1 and IC2 can be changed to give different maximum gain settings for each input. You could, for example, reduce the gain of inputs 1 & 2 so that they can accept signals up to 1-2V

RMS, suitable for use with a CD or DVD player while leaving inputs 3 & 4 with a high gain to suit microphones or a guitar. Or you could increase the gain of one channel above the nominal 31dB to suit a microphone with a very small output signal.

The easiest way to change the gain of each input is to change the values of R1 and C1 for channel 1, R2 and C2 for channel 2 and so on. Smaller values for these resistors increase the gain and larger values decrease them. The associated capacitor is changed at the same time, to keep the frequency response constant. The table on the circuit diagram shows various options for these components but other combinations are possible.

You can also alter the gain for all inputs by changing the 39kΩ resistor between pins 8 and 9 of IC3c. A higher value resistor will give you more overall gain but will also increase the noise and distortion. So for example, if you change the 39kΩ resistor to 82kΩ you will double the overall gain while changing it to 22kΩ will halve it.

It may be possible to gain a slight improvement in performance by replacing the TL072 and TL074 op amps with OPA2132/2134 or similar. However, the benefits will be marginal as other factors already limit the performance.

It is possible that some devices such as iPods and MP3 players may not work with the mixer as published as there is no DC path for the input signals to flow to ground. This can easily be solved with the addition of a resistor (eg, 100Ω) connected across the input for that channel. Probably the easiest

Improvements to a popular design

Since the original 4-channel mixer was presented in SILICON CHIP in January 1992, audio design has come a long way and it was possible to make quite a few improvements in performance without adding much to the overall component count. So we have made significant improvements to the original circuit and the PCB, as follows:

1) Added RF filtering, consisting of 100Ω resistors and ferrite beads in series with each input and a 100pF capacitor to ground. These compents greatly reduce RF break-through. Testing with the prototype showed no suggestion of radio signal break-through.

2) Increased the input impedance from 10kΩ to 1MΩ, so that musical instruments with inductive pickups suffer less high frequency loss.

3) Increased the size of many of the inter-stage AC-coupling capacitors from 2.2µF to 10µF, to reduce low-frequency distortion and give a more extended bass response. At the same time, we opted to use 470nF MKT capacitors at the input instead of polarised 2.2µF electrolytic types, again to obtain lower distortion.

4) Added full AC-coupling for the input volume pots, to reduce crackle when they are turned (especially as the pots age).

5) Lowered feedback resistor values throughout, to reduce noise and hum pick-up. The feedback resistors around the initial amplifier stages have been greatly reduced, from 22kΩ/1.2kΩ to 1.8kΩ/220Ω. This results in a 70% reduction in Johnson noise, one of the predominant sources of noise in the circuit. The mixer resistors are also reduced from 47kΩ to 10kΩ.

6) Split the signal gain between the input amplifier and mixer stages. This allows line level signals of up to 900mV RMS to be fed in before clipping occurs with a ±15V supply, compared to 500mV with the original design. The maximum gain is also increased from 26dB to 31dB, to suit a wider range of microphones.

7) Slightly extended the upper frequency response, for a -3dB point at 45kHz.

8) Changed mixer to a virtual earth configuration. This eliminates interactions between channel volume settings, allows for increased gain and reduces inter-channel crosstalk for those which are turned to minimum volume. It also has the advantage of inverting the signal, which is then re-inverted by the tone control circuit, avoiding the need for a final inversion to keep the inputs and output in-phase.

9) Added provision for either PCB-mount RCA sockets or terminal blocks for inputs and output. The original design used PC stakes.

10) Added an on-board power supply. The original design required a regulated split rail power supply. This one can run from 15V AC (plugpack or small mains transformer) or from single-rail or split rail DC. The op amp stage freed up by changing to a virtual earth mixer is used as a rail-splitter (ie, virtual earth generator) for single-supply operation.

11) Added an on-power power indicator LED (which may also be mounted off-board, eg, on the front panel of the unit).

12) Reduced the op amp package count to three by replacing two of the LM833s with a TL074.

13) Reduced the size of the PCB to 198 x 60mm (compared to the original at 249 x 113mm).

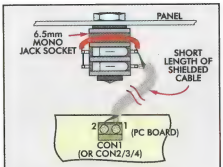


Fig.7: how to wire a standard switched phono jack as a shorting jack and connect it to the PCB. This is highly recommended as otherwise, unconnected inputs may contribute noise and hum to the output of the mixer.

way to do this is between the terminals of CON1a, CON2a, etc – even if there other cables going in there!

However, an input modified in this manner will no longer work with some microphones, guitars and other devices with a high output impedance (normal 600 ohm "dynamic" microphones will not be too badly affected).

Phantom power for condensor microphones

It would arguably be fairly unusual for condensor microphones to be used with a mixer such as this but it is possible.

The difficulty is that condensor microphones require a DC supply on their output (known as "phantom" power), normally around 16-48V at 1-2mA and uses the microphone cable itself to feed the microphone.

Because the inputs to the op amps are AC-coupled, feeding DC "up the line" will have no effect on the mixer. Phantom power can therefore easily be achieved by connecting a bypassed DC supply between the positive supply and the "hot" side of the microphone input.

We have made provision for this on one channel only, channel 4, with R5, R6 and a 100µF bypass capacitor. If you do not require phantom power, you can simply leave out these three components.

In fact, you should not connect phantom power to a microphone that doesn't need it. Putting a DC bias on a dynamic microphone's voice coil, for example, will usually result in a lower (or no) output and may even permanently damage the microphone.

Making inputs truly versatile

We designed this mixer to be as simple as possible to build with everything "on board". This assumed that constructors would nominate the input device required for each channel and fit appropriate resistors and capacitors for R1, C1, and so on (as per the table on the circuit).

But what if you needed to regularly swap inputs with devices that had different signal levels? It happens often in, for example, a band – or where various microphones are required to suit vocals or instruments.

It would be quite simple to fit a multi-pole switch to any or all of the input op amps and so switch various values of R&C.

For most applications, the input bias resistors will be satisfactory. However, you could bring these all down to 100kΩ if you really want to.

Small double pole (or "changeover") slider switches are available with up to four positions (eg, Altronics S-2040), so you could in theory fit four different values of R&C on the switch (again, as per the table on the circuit) and then be able to select the input level required according to the device being connected and, of course, its signal level. (See fig.8).

Alternatively, small rotary switches

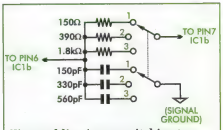


Fig.8: adding input switching to one or more channels is really easy and makes the mixer much more versatile (but does complicate construction a little). Here we've shown a 2-pole, 3-position switch capable of selecting a microphone (1), guitar (2) or line-level (3) source. 2-pole rotary switches with up to six positions are also available if you want more switchable inputs.

can be configured to have two poles and six positions so most of the variations shown on the circuit diagram could be accommodated.

The resistors and capacitors could be wired directly to the switch and three wires (eg, rainbow cable) run to the appropriate positions on the PCB (ie, the positions which would have been occupied by R1, C1 etc).

Want more than four channels?

Getting greedy, aren't we!

Seriously, adding additional channels to a design of this type is easy – you simply build additional input circuits – up to and including the 10kΩ resistor after the individual channel "gain" pots (VR1-4).

The "mixed" output of the four new channels is simply connected to the negative side of the 47µF capacitor before the existing IC3c, just as happens now.

Power (ie ±15VDC), can be taken from a suitable point on the existing mixer – the supply will handle it – and signal and supply grounds also connected to a suitable point. SC

Resistor Colour Codes

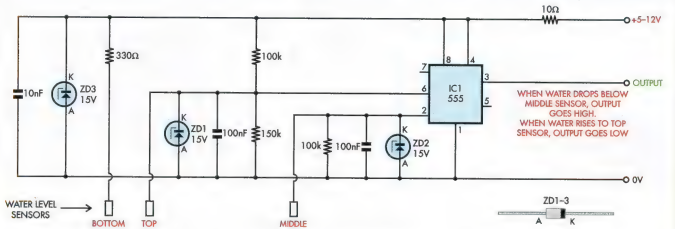
No.	Value	4-Band Code (1%)	5-Band Code (1%)
4	1MΩ	brown black green brown	brown black black yellow brown
2	100kΩ	brown black yellow brown	brown black black orange brown
1	39kΩ	orange white orange brown	orange white black red brown
9	10kΩ	brown black orange brown	brown black black red brown
4	6.8kΩ	blue grey red brown	blue grey black brown brown
5	1.8kΩ	brown grey red brown	brown gey black brown brown
4	220Ω	red red brown brown	red red black black brown
5	100Ω	brown black brown brown	brown black black black brown
1	33Ω	orange orange black brown	orange orange black gold brown

Capacitor Codes

Value	µF Value	IEC Code	EIA Code
470nF	0.47µF	470n	474
100nF	0.1µF	100n	104
22nF	0.022µF	22n	223
2.2nF	.0022µF	2n2	222
1.5nF	.0015µF	1n5	152
100pF	NA	100p	101
47pF	NA	47p	47

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Tank water level circuit with hysteresis

This circuit simulates a water tank float valve in that it has the hysteresis missing in other electronic level sensor circuits. It delays the pump from coming on every time the water level drops by only a small amount below the top probe as water is drawn from the tank.

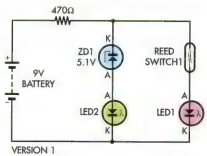
This circuit uses a 555 (IC1) to drive a solid-state relay but a standard relay could be used instead to control the pump. Three stainless steel rod probes are cut to lengths as required and are hung from the top of the tank. The longest, reaching to the bottom of the tank, supplies a common positive voltage into the water with the current limited to about 50μA via a 330Ω resistor.

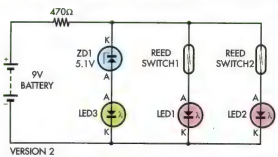
The middle probe, connected to pin 2, acts as the pump start trigger when the level drops below it. The top (shortest) probe, connected to pin 6, provides the pump stop signal when the level rises to it. Three-core flex can be used to connect between the tank probes and the controller.

With a full tank of water, all the probes are covered and the output from pin 3 of IC1 is low. As the water drops below the middle probe, pin 3 goes high and turns on the pump. The pump continues running until the water rises to the top probe at which point pin 3 goes low and turns off the pump. The distance between the middle and top probes sets the hysteresis. The advantage of this circuit is its simplicity and reliability.

The basic circuit has been in use for over 25 years for pump control on farms, using 2-pair underground telephone cables over distances of 100 metres between the tank sensor and pump controller. The 15V zener diodes were fitted after a lightning strike on the farm took out the 555 but they cannot guarantee zero damage in the event of another strike.

Peter Robertson, Walkerville, Vic. ($50)

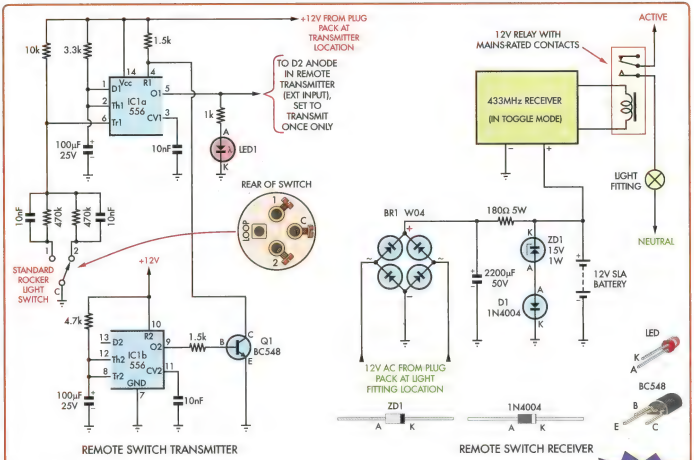




Really simple garage door monitor

The 433MHz garage door monitor presented in these page in the April 2012 issue is an elegant solution where wiring between the garage doors and the monitoring position is impractical. However, if it is easy to run wiring, this very simple circuit (Version 1) will enable you to tell whether the garage door (or any door) is open or closed.

It employs just two LEDs, one reed switch, a 5.1V zener diode, a 9V battery (or DC plugpack) and a 470Ω resistor. Only one length of figure-8 cable needs to be run from



433MHz remote lamp switching

This circuit was devised to overcome a problem of switching lights mounted on a concrete fence at the entrance to a property. Conduit and cabling was run from the switchboard on the side of the house but running wiring to a switch inside the house was difficult and impractical. Instead, this circuit allows a standard rocker light switch as made by HPM or Clipsal to be used with the 433MHz Remote Switch described in SILICON CHIP, January 2009.

When the switch is turned on, a brief negative-going pulse is applied to pin 6 of IC1a via a 10nF capacitor. This is configured as a monostable which applies a brief trigger pulse to the 433MHz transmitter module. LED1 gives an indication of the output pulse. The 433MHz receiver module is set to toggle mode and it turns the light on via its relay.

When choosing the timing components for IC1a, the time between switching on and off should be kept at least two seconds apart.

When the light switch is turned off, the same sequence of events is initiated by the second 10nF capacitor (at terminal 2 of the rocker switch) and the light is turned off.

The second monostable, IC1b, is provided to avoid malfunctions if there is a blackout. When power is first applied or restored, its pin 9 goes high for a few seconds, switching on Q1 which pulls pin 4 low. This disables IC1a so that it will not be triggered during that period by the 10nF capacitors. After that period, the circuit behaves normally.

At the receiving end, blackouts are catered for by using a 12V SLA battery which is trickle-charged by a 12V AC plugpack.

Geoff Coppa,
Toormina, NSW.

Editor's note: kits for the 433MHz remote switch project are available from Jaycar Electronics (Cat KC-5473) and from Altronics (K-1955 & K-1956).

Geoff Coppa is this month's winner of a $150 gift voucher from Dare & Farben.

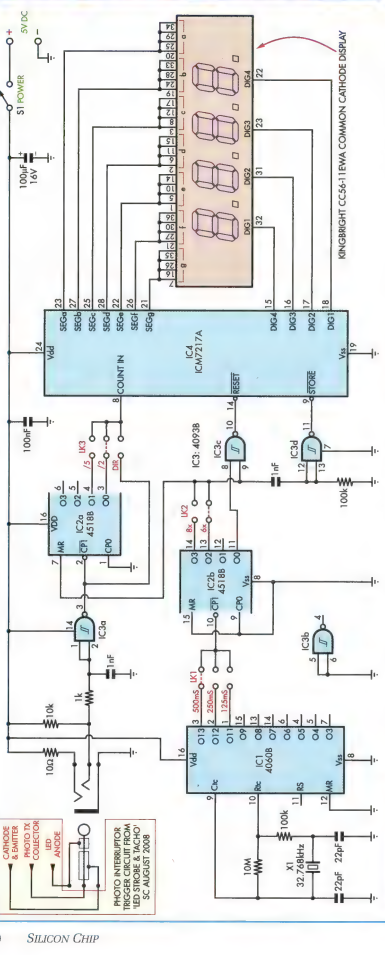
the garage door. The reed switch is installed so that it is closed when the garage door is closed. This causes LED1 to light.

When the reed switch is open, LED1 is dark and LED2 is lit and the assumption is that the door is fully open.

If you want to be sure that the door is fully open, you need another reed switch and an additional LED, as shown in Version 2 of the circuit. This will need three wires run from the garage door rather than two.

The second reed switch is installed so that it closes when the door is fully open. With this arrangement, LED1 is alight when the door is shut, LED2 is alight when the door is fully open and LED3 is alight when the door is in an intermediate position.

Robert Hall, ($40)
Massey, NZ.



Optical tachometer uses photo-interrupter

This circuit was designed to display the speed in RPM of model Stirling engines fitted with a slotted flywheel and a photo-interrupter trigger. It can measure up to 9999 RPM and leading zeroes are automatically blanked. The trigger input is compatible with the LED Strobe & Tachometer described in the August 2008 issue and any of the trigger circuits from that project can be used.

The timebase is derived from a 32kHz watch crystal using a 4060 14-bit counter and oscillator IC1, to produce a clock signal of 125, 250 or 500ms, as selected by link LK1. BCD counter IC2b is used to generate the STORE and RESET control signals for IC4, an Intersil ICM7217A 4-digit decade counter/display driver. It drives a Kingbright CC56-11EWA 4-digit 7-segment LED display.

Note that the LED digit numbering differs between IC4 and the Kingbright display. The most significant digit (MSD) is labelled DIG4 on IC4 but is digit 1 on the LED display. The decimal points are not used.

Link LK2 selects either six or eight cycles of the gate clock to allow for a range of slots in the flywheel. The trigger input is buffered by IC3a and divided down by IC2a. LK3 selects either the direct input (no division), divide-by-2 or divide-by-5 to drive the clock input of the 4-digit counter.

Table 1 shows how to select the links for various numbers of slots. The circuit diagram is shown with the links set for a 100-slot flywheel disc, ie, one that generates 100 pulses per revolution. In this case LK1 is set to 500ms, LK2 to six counts and LK3 to divide the input by five. So if the flywheel was turning at 60 RPM (one rev/sec) it would rotate three times in the 3-second gate period, resulting in 300 trigger pulses. Dividing by five results in the correct 60 RPM display on the counter. Note that no input signal will result in a blank display due to the ICM7217A's in-built leading zero blanking.

The prototype used an ICM7217A which has been discontinued by Intersil but Maxim are still producing the device. The timebase circuit could also be used with a 74C926 4-digit counter with the following modifications: invert the RESET-BAR signal from IC3c pin 10 (use IC3b) and con-

Table 1: Pulses Per Revolution (P/R) For RPM Display

LK1 Gate Clock ms	LK2 Gate Count cycles	Gate Period secs	LK3 Direct P/R	LK3 Divide 2 P/R	LK3 Divide 5 P/R
125	6	0.75	80	160	400
125	8	1	60	120	300
250	6	1.5	40	80	200
250	8	2	30	60	150
500	6	3	20	40	100
500	8	4	15	30	75

Accurate clock uses Maximite and Garmin GPS module

Based on the very popular Maximite (SILICON CHIP, March-May 2011), this GPS clock display reads the NMEA string from a Garmin 16HVS GPS module and gives a very accurate indication of the time. It also displays date, day of the week and day of the year.

The pushbutton (S1) toggles the display between time and position. There is also an output that will light a LED to show an alarm. It is set to toggle high for two seconds every minute, four seconds every hour and six seconds every 24 hours. The rising edge of this alarm occurs about 800µs after the pulse per second (PPS).

The NMEA string contains all the necessary information for the display. Normally, the GPS module will output the NMEA string after the PPS and if it is displayed at that time it will be about 500ms late. The program receives the NMEA string from the GPS, strips the necessary information (parsing), adds 1s to the time and waits for the next PPS. It then updates the display. This ensures the correct time is displayed.

The time it takes to update the first line of the display is less than 45ms; almost indiscernible to the eye. On the 24-hour changeover, the date will update one second late.

The Garmin module is set to output the $GPRMC string at 19200, 8, N, 1 and the PPS is set to a width of 20ms. The Garmin website gives information on how to program the module.

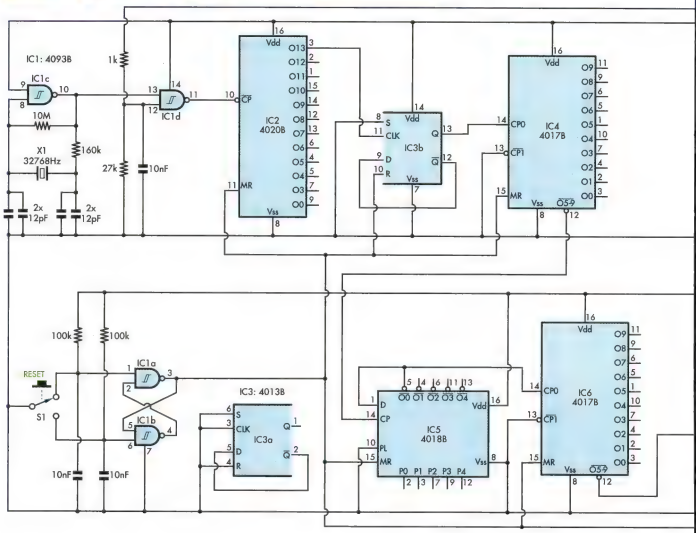
Any GPS module can be used so long as it can be programmed and will provide a PPS. This is essential for synchronisation to the correct time. A GPS 15L module with a GA 29F antenna could be used in place of the 16HVS.

The software (garmin1.bas) can be downloaded from the SILICON CHIP website.

Trevor Dalziell,
Canberra, ACT. ($50)

nect to RESET (74C926 pin 13); connect the STORE-BAR signal from IC3d pin 11 to LATCH ENABLE (74C926 pin 5) and connect the DISPLAY SELECT (74C926 pin 6) to ground.

Geoff Nicholls,
Hamburg, Germany. ($50)



Engine hours counter

This timer circuit is used for a machine, such as a large air compressor, that requires regular maintenance after a fixed number of hours. Because it uses discrete logic ICs instead of a microcontroller, it is fairly complex but the CMOS chips are all cheap and readily available.

Essentially, the circuit is a crystal-controlled counter that displays the number of hours that the machine has been running on a 2-digit 7-segment LED display. The circuit is connected to the ignition switch and the machine's 12V battery.

When the ignition switch is off, the counter stops, the 2-digit display is off and the circuit draws about 800µA from the battery. This is necessary to retain the counter value. When the ignition switch is on, the clock runs and the number of hours run is displayed. A reset switch is provided to set the counter to zero and is pressed after the required service has been completed.

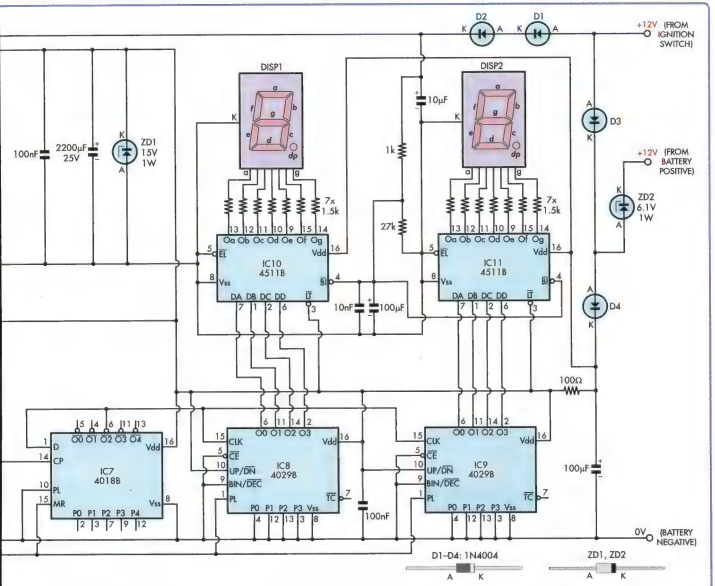
IC1d, one inverter in a 4093 quad

Issues Getting Dog-Eared?

Keep your copies of SILICON CHIP safe with these handy binders

Available Aust. only. Price: $A14.95 plus $10.00 p&p per order (includes GST). Just fill in and mail the handy order form in this issue; or fax (02) 9939 2648; or call (02) 9939 3295 and quote your credit card number.

REAL VALUE AT $14.95 PLUS P&P



2-input Schmitt trigger inverter package, is connected as a crystal oscillator running at 32.768kHz. Its signal is coupled via IC1c which is gated off when the ignition switch is off and on if the ignition is on. From there it is applied to a frequency divider comprising IC2, IC3b, IC4, IC5, IC6 & IC7 to divide the 32.768kHz crystal frequency by 117,964,800. This gives one pulse per hour.

This is fed to two cascaded 4029 decade counters, IC8 & IC9. Their BCD outputs are fed to two 4511 BCD to 7-segment decoder drivers, IC10 & IC11. These two last ICs drive the two LED digits to display the run time.

Gates IC1a & IC1b are wired as an RS flipflop to provide a reset pulse when momentary switch S1 is pressed. This pulse resets the counters and the display to zero. Zener diode ZD2 is used to reduce the 12V counter supply to approximately 5V when the ignition switch is off. This reduces the supply current to a low value.

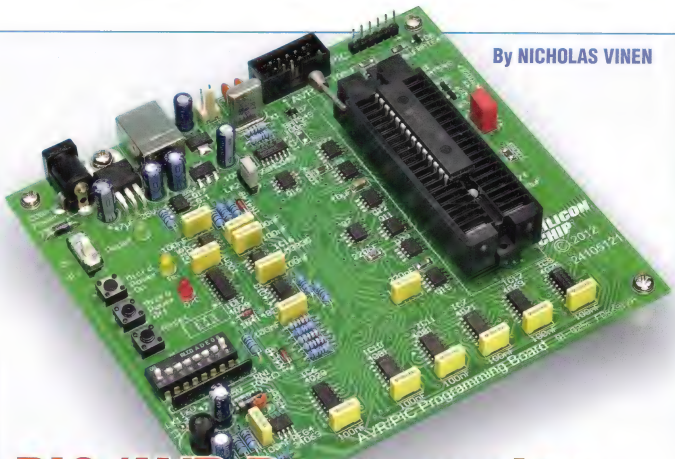
Les Kerr,
Ashby, NSW. ($60)

contribution
May the best ~~man~~ win!

As you can see, we pay $$$ for contributions to Circuit Notebook. But each month the **best** contribution (at the sole discretion of the editor) receives **a $150 gift voucher from Hare&Forbes Machineryhouse.** That's yours to spend at Hare&Forbes Machineryhouse as you see fit – buy some tools you've always wanted, or put it towards that big purchase you've never been able to afford! Contribute **NOW** and **WIN!** Email your contribution now to editor@siliconchip.com.au or post to PO Box 139, Collaroy NSW

HARE&FORBES MACHINERYHOUSE
ABN: 90 000 286 957
www.machineryhouse.com.au

By NICHOLAS VINEN



PIC/AVR Programming Adaptor Board; Pt.2

Last month, we described our new programming adaptor board which works in conjunction with an In-Circuit Serial Programmer (ICSP) to program most 8-bit & 16-bit PIC and 8-bit Atmel AVR microcontrollers. Here, we give the details of how to build it and how to use it.

AS NOTED LAST MONTH, virtually all the semiconductor devices in the PIC/AVR Programming Adaptor are surface-mount, apart from the diodes and LEDs. This approach has been taken otherwise the PCB would have been impractically large.

Even so, the double-sided PCB is fairly densely populated on the topside and has quite a few SMDs underneath as well. However, we have specified SMDs with a "reasonable" pin spacing so they should not be too challenging to solder.

The double-sided PCB measures 116 x 127mm and has plated-through holes and vias. The PCB is available from the SILICON CHIP Partshop and is coded 24105121. It isn't practical to make the board yourself, given the number of vias, especially as some of them are located under components. The boards we provide not only have plated through-holes but also a solder mask and a silk-screened overlay on both sides to make construction as easy as possible.

Figs.4(a) & 4(b) show the component overlays for both sides of the PCB. Install the surface-mount parts on the top first. You can refer to the panel later in this article for a step-by-step procedure on hand-soldering SMDs.

Note that most of the SMD components are static-sensitive and so you should ideally build it on an anti-static mat or using some other method to prevent damage to the Mosfets and ICs.

Starting assembly

Start with the three small dual diodes (D6-D8) and then fit the four

Fig.4: the overlay diagrams for both sides of the PCB. Install the parts as shown here, paying close attention to the orientation of the ICs, Mosfets and electrolytic capacitors. Pin 1 is shown with a dot in one corner of the IC but in some cases there may be no dot and instead, a bevelled edge on the IC package indicates the side with pin 1.

2N7002P Mosfets. These diodes and Mosfets look virtually identical so be careful not to get them mixed up.

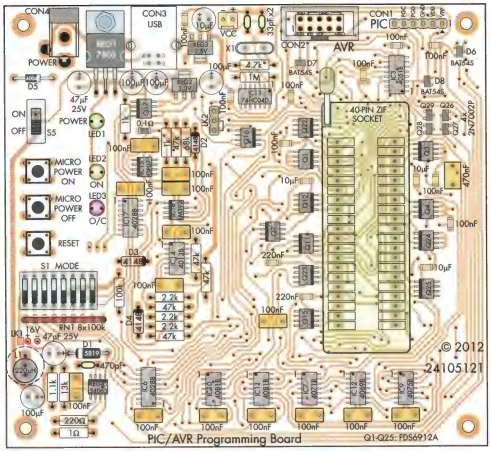
Follow with the 13 FDS6912A dual Mosfets that go on the top of the board. They are in 8-pin SOIC packages and are not all orientated in the same manner so check carefully that each one is the right way around before soldering it in place. These Mosfets usually have both a bevelled edge on one side of the package and a dimple to indicate pin 1 – the position of both is shown on the overlay diagram.

There are also 13 ICs (including REG4) on the top of the PCB and they go in next. Again, their orientations vary so you should check each one carefully. Some of the ICs may have a dot or dimple indicating pin 1 but some will only have a bevelled edge so that is the most reliable way to tell which way they go in. Many of the ICs are in identical packages so take care that each type goes in its designated location.

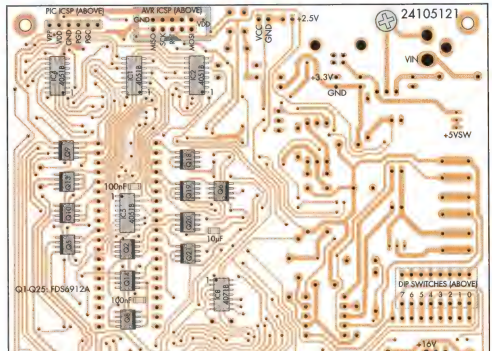
Regulators REG2 and REG3 can now be fitted. Solder the three pins and then the tab. Don't get the two mixed up. Then you can fit the passive SMD components, which consist of eight 100nF ceramic "chip" capacitors, two 220nF ceramic capacitors, three 10µF ceramic capacitors and one 0.1Ω SMD resistor/shunt.

It's now time to fit components to the other side so fit the four tapped spacers at each corner on the top side of the board, using M3 x 6mm screws. That done, flip it over and it will rest flat and level on the spacers rather than the components you have just finished soldering.

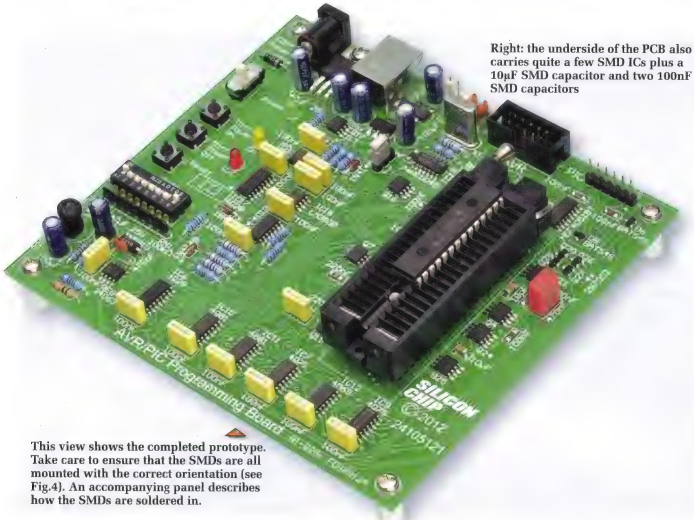
Refer now to Fig.4(b). There are a further 12 FDS6912A dual Mosfets so fit them now. Again, be careful with orientation as it varies. Follow with the five remaining ICs and then the three passive SMD components: one 10µF and two 100nF ceramic capacitors. You can then remove the tapped spacers and refit them on the other



(TOP OF BOARD)



(UNDER SIDE OF BOARD)



Right: the underside of the PCB also carries quite a few SMD ICs plus a 10µF SMD capacitor and two 100nF SMD capacitors

This view shows the completed prototype. Take care to ensure that the SMDs are all mounted with the correct orientation (see Fig.4). An accompanying panel describes how the SMDs are soldered in.

side of the board, in preparation for the next step.

Through-hole components

Now we come to the resistors. Check each value with a DMM before soldering it into place. Follow with the five diodes, orientated as shown on the overlay diagram. There are three different types so be sure to put them in the correct locations.

Mount the 40-pin production (or dual-wipe) IC socket next, with the notch at the top. Check carefully that its edges are parallel to the edges of the PCB before soldering more than a couple of pins, otherwise the ZIF socket will be crooked when it is inserted

Bend the leads of REG1 down 90° 6mm from the plastic body and then mount the tab onto the PCB using the remaining M3 x 6mm machine screw, a shakeproof washer and a nut. Do it up tight, then solder and trim the leads.

Fit the 9-pin resistor network next, with its pin 1 (usually indicated by a dot) towards the righthand end of the PCB. The 8-way DIP switch can then go in, with the text right-side-up as shown in the photos. That done, solder the three LEDs in place with their anodes to the right (flat sides to the left), followed by the MKT and ceramic capacitors.

Bobbin inductor L1 is next. There is an extra pad on the PCB so that you can fit different-sized chokes. If you're using the smaller type, make sure it is soldered across the bottom two holes. You can then fit slide switch S5 which can go in either way, although you may wish to mount it with the stamped "ON" text at the top.

Now solder in the 2-way, 3-way and 6-way pin headers (CON5, LK2 and CON1 respectively). Follow with the IDC socket (CON2) and then crystal X1. You can then fit all the electrolytic capacitors with the longer lead though the hole marked with a "+" symbol in each case.

The DC and USB sockets go in now. In each case, push them down fully onto the PCB and ensure they are aligned with the edge of the PCB before soldering their pins. Attach the USB socket's tabs to the mounting pads before soldering the smaller pins.

You can now mount the tactile pushbuttons after pushing them down firmly onto the top of the board. Orientate them so that the pins are on the left and right sides.

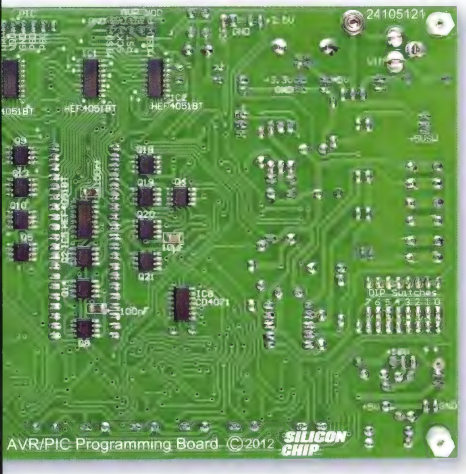
Testing

First, check that the power supply is operating properly. Move all the DIP switches to their lower (off) positions. The two pads for LK1 (below the DIP switches) must not be shorted together.

If you have a current-limited bench supply, set it for 9V and 100mA and connect it between a convenient ground point and the anode of D5. Otherwise, you can use a 9-12V DC plugpack. Leave S5 in the "off" position and then switch on the power supply.

Check the output of REG1, at its right-most pin. You can use the tab or mounting screw to connect the ground probe. You should get a reading very close to 5V. Assuming that's OK, switch on S5 and check that the green power LED lights up.

There are two small round pads to the right of LK1, below the DIP switch bank, labelled "+" and "-".



These allow you to check the output of REG4, which should be close to +16V. However, since they are quite close together, you may find it easier to measure between TP1 (the positive test point) and the same ground point you used earlier, eg, REG1's tab.

Confirm that REG4 is providing around 16V. If not then switch off and check it and the surrounding circuitry for faults such as incorrectly orientated components or bad solder joints. Assuming that it's OK, measure the output of REG2 at its tab, relative to the same ground point you used earlier. You should get 3.3V.

You can now disconnect the power supply and short LK1's pads together using a small blob of solder. Set up the DIP switches for the PIC18F2xJ5x series of microcontrollers, as shown in Fig.5. Apply power, turn power switch S5 on and then press the "Micro Power On" pushbutton. The yellow LED should light up. If the red LED lights up, switch off and check for faults in the power supply circuitry.

Check the voltage at pin 32 of the ZIF socket (adjacent to pin 9), relative to a convenient ground point, eg, the tab of REG1. You should get a reading of around 3.3V. Check that pins 8 and 31 read very close to 0V. They should not be floating which normally gives a reading somewhat above 0V.

Now set your DMM to continuity mode and check that there is a good connection between pin 1 of the ZIF socket and the V_{PP} pin of CON1 (rightmost). Check this in both directions, ie, swap the multimeter probes around and ensure that there is a connection either way. You can then perform the same test to check that ZIF socket pin 40 (upper-right) is connected to PGD (CON1, third-from left) and that socket pin 39 connects to PGC, the second-from-left pin of CON1.

Now use the DMM to check that the five right-most pins of CON1 are not connected to each other. You may get a brief beep out of the multimeter with the probes between V_{DD} and GND due to power supply bypass capacitance. There should not be continuity between PGD, PGC and V_{PP}.

Assuming that your DMM also has a capacitance mode, measure the capacitance between pins 6 & 8 of the ZIF socket. This should be around 10µF. Much less than that indicates a fault.

If that all checks out OK, chances are good that your programming adaptor board is working properly. You could test other modes in a similar manner, referring to the relevant microcontroller data sheets, but it would take a while to check all the various modes.

It's now time to install the ZIF socket, with the lever towards the top of the board. Support the PCB underneath the socket and press it down hard. Its large pins are a tight fit but they should go in with some effort and it won't easily come off again unless you really need to remove it. The unit is now ready for use.

Using it

Figs.5 & 6 provide the instructions you need to operate the unit. These can be copied and laminated to keep with the unit. Note that it's generally not a good idea to change the positions of the DIP switches while the unit is switched on as the design assumes that all the logic is static. This also avoids the possibility that you might accidentally change to the wrong mode while a microcontroller is in the ZIF socket and powered up.

Note that some PICs require 5V for programming even though they can run at 3.3V (eg, PIC12F675). For this reason, it's generally best to program with a 5V supply if the micro is rated to operate at 5V, which may require different DIP switch settings than those shown in Fig.5. If in doubt, check the data sheet.

Generally, LK2 can be left in its default position, with the jumper shunt across the bottom two positions. That way, the in-circuit programmer receives power at the same time as the micro and so it won't try to "probe" it when it is unpowered.

But if the programmer is to provide power for the micro and you want to be able to switch it using the on-board power on/off buttons, you can move the shorting block to the other position. In this case, the programmer's V_{DD} pin is the source of voltage for the micro power supply circuitry, including the electronic fuse (although in-circuit programmers normally provide some form of current limiting too).

Programming dsPIC30s

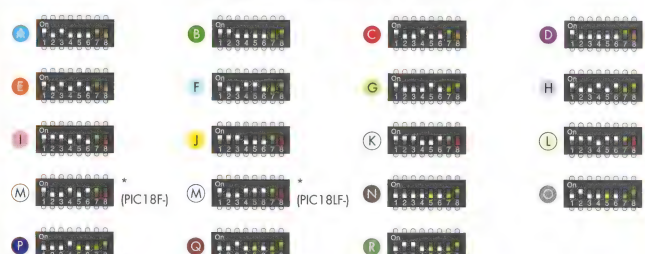
We last published a PIC program-

Setting The DIP Switches & Programming The Device

PIC/AVR Programming Adaptor Board Device Selection

PIC12F-, PIC12HV-	(A) All
PIC16F-, PIC16LF-	(A) 50x, 51x, 526, 63x, 67x, 68x, 690, 720, 721, 785, 145x, 150x, 1823-1825, 1828, 1829 (B) 54, 7x, 8x(A), 540, 61x, 62x(A), 648(A), 716, 1826, 1827, 1847 (C) 722-726(A), 737, 767, 882, 883, 886, 913, 916, 15xx, 17xx, 1906, 193x (D) 707, 747, 777, 87x(A), 884, 887, 914, 917, 1904, 1907
PIC18F-, PIC18LF-	(A) 1xK2x (D) 4x1x, 4x2x, 4x3x, 4x8x, 4xK2x, 4xK8x (B) 1220, 1230, 1320, 1330 (E) 1xK5x (G) 4x5x (M)* 2xJ5x (C) 2x1x, 2x2x, 2x8x, 2xK2x, 2xK8x (F) 2x5x (H) 2xJ1x, 4xJ1x, 4xJ5x
PIC24E-	(I) All
PIC24F-	(J) J16MC102 (J) 0xKA102, 0xKLx01, 0xKLx02 (K) JxxGAx0x (L) JxxGB00x
PIC24H-	(I) J16GP102, J16MC102, J32MC202, J32MC204, J16GP304, J32GPx0x, J64GPx0x, J120GPx0x
dsPIC33E-	(I) All
dsPIC33F-	(I) J12GP202, J12MC202, J32GP30x, J32MC30x, J64GPx0x, J64MCx0x, J128GPx0x, J128MCx0x
ATtiny-	(N) 13(A)(V), 15L, 25/45/85(V) (O) 26(L), 261/461/861(A)(V) (P) 2313(A)(V), 4313 (Q) 48/88
ATmega-	(Q) 48/88/168/328(P)(A)(V), 8(A)(L) (R) 16/32(A)(L), 164/324/644/1284(P)(A)(V), 8535(L)

x = any digit 0-9 (P), (A), (V), (L) = optional letter suffix



Setting shown for 5V programming; 3.3V also suitable.

Setting shown for 3.3V programming; some micros may need 5V for programming.

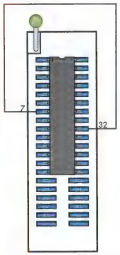
Setting shown for 3.3V programming; 5V not recommended and may be disabled.

(AVR only) External clock may be enabled. Use only if necessary.

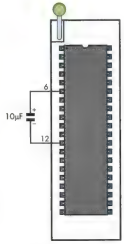
Fig.5: this diagram shows the supported devices along with the relevant DIP switch configuration. Look up the part series in the table at the top, then find the letter code for the particular suffix and set the DIP switches to the corresponding configuration. There may be some parts not listed here that can be programmed in one of the modes.

PIC/AVR Programming Adaptor Board Step-by-Step Guide

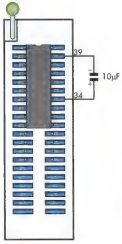
1. Set power switch in "off" position
2. Look up device to be programmed in Device Selection sheet and set DIP switches as shown.
3. Lift ZIF socket level and insert microcontroller with pin 1 at upper-left. Hold microcontroller steady and push lever down until it locks.
4. Launch PC software, select correct target device and connect programmer to CON1 or CON2. Do not connect both PIC and AVR programmers at the same time.
5. Switch on power to programming adaptor board. Check that green LED is lit.
6. Press "Micro Power On" pushbutton. The yellow LED should light up. If red LED lights instead, press "Micro Power Off" button and re-check DIP switch positions.
7. If providing external microcontroller power (eg, from PICkit3), enable it now.
8. Check device signature using PC software. This is automatic with Microchip MPLab. Assuming it is correct, you can then proceed to program, read and/or verify the flash memory in the target microcontroller as required.
9. If providing external microcontroller power (eg, from PICkit3), switch it off now.
10. Press "Micro Power Off" pushbutton and switch board power off.
11. Lift ZIF socket lever. The microcontroller can be safely removed.



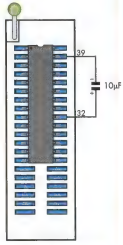
Insert a wire link in the ZIF socket as shown here to program PIC18F2331 or PIC18F2431 micros in mode (C).



An extra 10µF tantalum or ceramic capacitor is required to program PIC18F44J10 or PIC18F45J10 micros in mode (D).



An extra 10µF tantalum or ceramic capacitor is required to program PIC24FVxxKA301 but not PIC24FxxKA301 micros in mode (K).



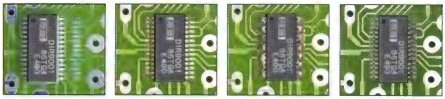
An extra 10µF tantalum or ceramic capacitor is required to program PIC24FVxxKA302 but not PIC24FxxKA302 micros in mode (K).

Fig.6: here are the instructions for using the unit, along with the special case devices which can be programmed with an extra wire link or 10µF capacitor inserted in the ZIF socket. Ensure that this extra component is well clamped at both ends before applying power and take care with tantalum capacitor orientation.

mer in the May 2008 issue. This was called a "Low-cost Programmer for dsPICs and PICs" and it connected to the PC via a serial port. That project required the now-defunct WinPIC software which is still available but is not being updated to suit newer micros or the latest Windows operating systems.

Most constructors would be better off with the new design described here because it can handle a larger portion of the PIC range, works with up-to-date software and is easier to use. The one thing the previous unit can do that this one can't is to program dsPIC30F mi-

Soldering In The Surface Mount Devices (SMDs)



Installing an SMD IC: (A) place a small amount of solder on the top-right pad; (B) re-melt the solder & slide the IC, the solder the diagonally opposite pad; (C) solder the remaining pads (ignore solder bridges); (D) remove the excess solder using solder wick and clean up using isopropanol.

If you don't have a solder reflow oven, you can solder the SMDs one at a time, by hand. With a little practice, this isn't too difficult, especially since the parts used in this project have a relatively large spacing between pins.

You will need a temperature-controlled soldering iron with a medium-size or smaller conical tip, a magnifying glass (preferably a magnifying lamp), angle-tip tweezers, some desoldering braid (or solder wick) and a syringe of no-clean flux paste (Jaycar Cat. NS3039, Altronics Cat. H-1650). Don't try to attempt the job without these basic tools, otherwise you could wreck both the ICs and the board.

You don't need to use a very thin tip on the soldering iron. In fact, using a thin tip can make the process more difficult when it comes to applying enough heat to the solder wick and getting the solder to reflow properly. The standard tip supplied with most good irons should be sufficient and a medium to fine conical tip works well.

Be sure also to use fine, good quality solder (0.71mm diameter solder is ideal).

Step-by-step procedure

The step-by-step procedure for soldering in each SMD is as follows:

(1) Remove one part from the tube or tape packaging. With tape, peel back the clear layer using tweezers to expose one device at a time. Take care not to drop the smaller devices as they can be impossible to find if they land on the floor.

(2) Find the location for that component on the PCB. Place the board flat on the workbench with the right side up and orientated so that pin 1 will be at upper-left.

(3) Apply a tiny amount of solder to the top-right pad for the device (or top left if you are left-handed). To do this, briefly touch the pad with the soldering iron and add a dab of solder – just enough so that you can see smoke from the flux – then quickly remove the iron.

You should now be able to see a small solder bulge on that pad (check with a magnifying glass if unsure).

(4) Clean the tip of the iron with a damp sponge to remove any excess solder.

(5) Place the component next to (but not on) the pads. If you are right-handed, place it slightly to the left of the pads and vice versa.

(6) For leaded components (ICs, Mosfets and diodes), check that the leads are resting on the PCB surface. Capacitors and resistors should lie flat on the board. For resistors, keep the label side up.

(7) Check that the component orientation is correct. For ICs, ensure that the corner dot/dimple or bevelled edge is on the lefthand side. SOT-23 FETs and dual diodes have a triangular pin layout so the necessary orientation should be clear. Other components (resistors, capacitors) are not polarised and orientation is not important.

(8) Grab the part by its sides using a pair of angled tweezers.

(9) Use the soldering iron to melt the solder on the top right pad, then gently slide the part along the board and into place. Remove the soldering iron immediately it is in place.

This process should only take a couple of seconds, to avoid overheating the pad and the component.

Current Limit Adjustment

Once you have finished programming a chip, by default it will immediately begin executing the new program code. However, while the electronic fuse current limit has been chosen to supply sufficient current for programming the micro, in some cases it may not be enough once it starts operation, especially with high-speed parts such as dsPIC33s. In this case, the micro power will trip off immediately after programming is complete and you will lose the ability to perform further operations, even if you reset the micro power supply.

There are two solutions to this. The first is to set the in-circuit programmer to hold the micro in reset once programming is complete. This can be done in Microchip MPLAB via the Programmer menu using the "Hold In Reset" option. However, this option is only available when the programmer is operating normally so you have to do this first.

The other option is to increase the current limit to allow the micro to operate once it is programmed. This can be done by reducing the value of the 68kΩ feedback resistor across IC15 (adjacent to D2 on the PCB). For example, substituting a 47kΩ resistor increases the current limit to around 130mA. Avoid increasing it much more than this; if the current limit is high enough, you risk damage to the micro under fault conditions.

cros. While a small range of dsPIC30s is still available, they have essentially been made obsolete by the dsPIC33F and dsPIC33E/PIC24E series.

As a result, we don't expect many people still use them. If you need to program one, you could use the May 2008 programmer or alternatively, build a programming jig on stripboard.

USB power

Finally, if you are going to run the board from USB power, it generally draws less than 100mA. However, depending on the exact configuration and the micro being programmed, it could draw more so it's a good idea to run it from a computer host port or a powered hub, especially since it has no circuitry to negotiate power allocation from the host computer.

Don't worry about getting it in exactly the right place the first time. Just try to avoid getting any solder on the other pins. As long as you do that, repositioning the part is easy.

(10) If the part is not exactly lined up with the pads, simply re-melt the solder and nudge it until it is. Wait a few seconds between each attempt. When the part is correctly lined up, all its pins will be centred on their pads.

(11) Once you are happy with the alignment, re-check that the component orientation is correct, then rotate the board 180° and solder the pin at the opposite corner. It shouldn't move much during this step but if it does, reheat the joint and adjust it as necessary.

(9) Now solder the rest of the pins. The parts used here can be successfully soldered one pin at a time without forming bridges but don't worry if you do get bridges as they are easily removed later. It's more important to make sure that solder has flowed onto all the pins and pads.

(10) Even if you have no bridges, it's recommended that you apply a thin layer of flux paste along both rows of pins, towards the outside. A thin layer should be enough (you can always add more later if necessary). You can now remove any excess solder.

That's done by placing a length of solder wick immediately alongside (but not on top of) some of the pads. Now place the soldering iron on top of the solder wick, pressing it down onto the board, while gently sliding the wick towards the solder on the pads.

As the wick heats, it will start to melt the flux and the excess solder, creating visible smoke. At that point you can slide it right up against the pins. Most of the excess solder should then be sucked into the braid. Finally, slide the wick along the board away from the pads and lift it and the soldering iron off the board.

At all times, you should be pressing down onto the PCB only while sliding the wick along it. The whole process should take no more than about 5-6 seconds.

Don't worry if some solder bridges are left behind – rather than applying the heat for too long, it's better to remove what's left with a second pass. When you are finished, the pins should be left with a near-perfect amount of solder and no bridges.

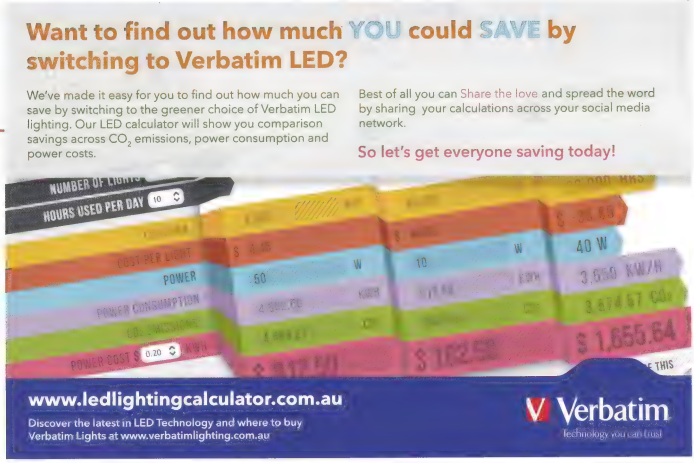
The reason we recommend that you do this even if there are no visible bridges is that it virtually guarantees good solder joints by reflowing the solder with the additional flux. Otherwise, it's possible to get a joint that a cursory check suggests is OK but on closer inspection, the solder has adhered to the component pin but has not flowed down onto the pad below it.

(11) Repeat the above process for the other side of the component.

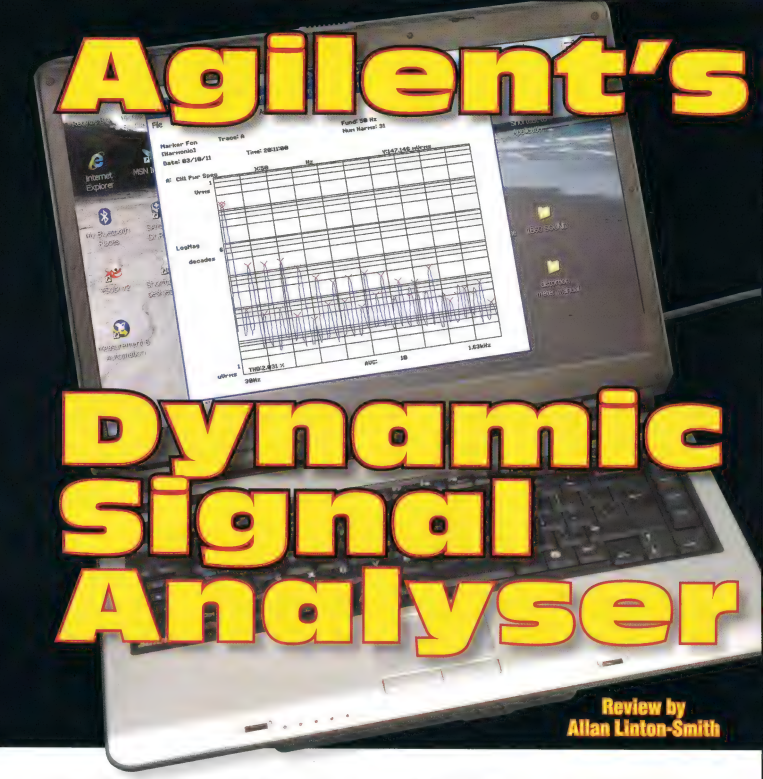
(12) Inspect the part using a magnifying glass to check for any solder bridges or bad joints. If there are solder bridges, apply a little flux and then use the solder wick to clean it up.

(12) If you are using no-clean (non-corrosive) flux (ie, the recommended type) then you theoretically don't need to clean off the flux residue. However since this board won't necessarily be installed in a housing, it's a good idea to clean the sticky flux off it using pure alcohol (eg, isopropanol).

Finally, if you do get flux on your hands, be sure to wash them as it can be toxic. **SC**



Agilent's Dynamic Signal Analyser



Review by Allan Linton-Smith

The Agilent 35670A has been around for many years and has become virtually the industry standard for sound and vibration engineers. As well as carrying out audio analysis, it is equally at home with measurement applications in aeronautical, structural, mechanical, civil, automotive and electronics engineering.

It can be used for everything from analysing microphones to earthquakes, from examining bridges and beams for metal fatigue to vibration in motors.

The 35670A has been in production for quite a few years and has not undergone any significant updates in that time, so it still looks and feels like a 1990s instrument.

On the other hand, it is a real workhorse in the field, built to withstand tough conditions and able to be operated from mains or battery. But it is also a very accurate bench top instrument with many useful features not readily found elsewhere. So in effect, the Agilent 35670A is "an oldie but a goody".

What other instrument can analyse a bridge beam or automobile chassis, analyse for metal fatigue or troubleshoot engine problems?

One of the photos in this review shows a typical automotive test for analysing road and engine noise. Sensors can be placed at various locations around the vehicle and a connection made to the tachometer input for determination of noise vs RPM.

Closer to the interest of those in the SILICON CHIP offices, it measures THD and does spectrum analysis (via FFT) simultaneously on two channels. You can also "save to table" and observe or print out the value of each harmonic in the spectrum analysis.

It is extremely sensitive and can accurately measure RMS voltages down to the nanovolt region, which is important when using accelerometers and sensors. (Most audio analysers have trouble analysing RMS levels less than 10mV.)

It has a 16-bit ADC (90dB dynamic

The rear panel houses sockets for the GPIB interface, keyboard, serial and parallel ports plus power supply inputs (AC and DC) and power switching options. We used the blue GPIB-USB device to connect to our computer to download coloured traces.

range) and a real time bandwidth of 0-25.6kHz so you can be sure nothing will be missed. In the swept sine mode, the dynamic range increases to a whopping 130dB.

You can resolve signals using 100-1600 lines or for really close-in analysis, use the frequency zoom to resolve signals with up to 61μHz resolution. (Even very good spectrum analysers can only manage about 1Hz resolution!).

There is a facility for time or RPM arming to develop waterfalls of sequential vibration spectra for trend analysis, or for an overview of device vibration.

You can match your spectrum measurement mode to the signal being tested and use the linear spectrum analysis to measure BOTH the amplitude and phase of periodic signals such as the spectra of rotating machinery. Power spectrum analysis is provided for averaging non-repetitive signals.

In addition to all this, it can time-capture waveforms, measure phase distortion, side-band power, noise power, display spectral maps, waterfall displays, frequency response using both Fast Fourier Transform (FFT) or swept sine and it also has an optional arbitrary waveform generator. This latter option is also capable of generating repetitive waveforms which have been previously stored.

Various averaging modes let you further refine spectrum analysis measurements. Time averaging extracts repetitive signals out of the noise while RMS averaging reduces the noise to its mean value.

The instrument also has "exponential" averaging for both time and RMS volts. This is useful for reducing the noise while following changing signals, such as tracking the resonance shifts in a fatiguing structure; when metal fatigue happens the natural resonance changes drastically and is easily observed with this instrument.

Other features

The 35670A is a standalone instrument requiring no peripheral computer for general operation, although we used a small laptop PC to record traces and to add captions and colours.

The standard instrument allows you to look at signals in the frequency, time and amplitude domain and there are several options which are available to either add new measurements or enhance all measurement modes.

Options:

AY6 adds two channels (four total)
IDO computed order tracking

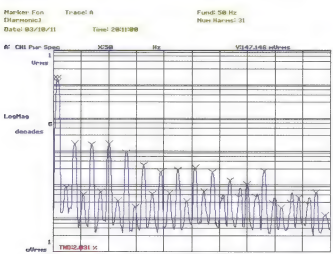


Fig.1: the trace shows 10 averages the spectrum of 50Hz mains harmonics up to 1.63kHz. The signal has been significantly attenuated to prevent instrument overload. Each harmonic is marked and a THD figure is calculated shown in red. In this case 31 harmonics can be read and the THD is 2%

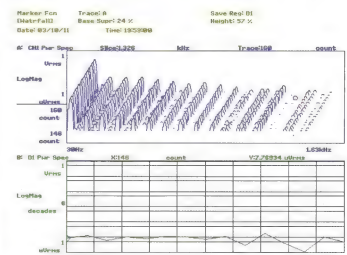


Fig.2: a spectrum waterfall of mains harmonics gathered at 160 specified time intervals. A base suppression of 24% was used to eliminate noise. The lower chart is a slice of activity between counts 146-160 where the red marker is positioned at 1.326kHz showing around 1 microvolt. Our mains harmonic distortion looks like a veritable graveyard!

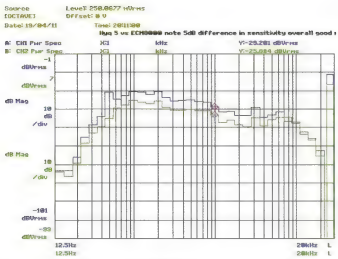


Fig.3: a comparison of the HYQ-5 microphone vs the Behringer ECM 8000 for our loudspeaker frequency response article (SC Dec 11) using the back/front display mode with the 1/3 octave real time option. Pink noise was used and fed to a loudspeaker and simultaneously picked up by both mics positioned closely. It can be seen that at 1kHz the HYQ-5 is only about 5dB less sensitive than the much more expensive calibrated ECM 8000 and is very close in response too!

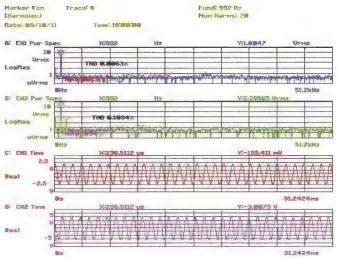


Fig.4: the blue trace shows harmonic distortion is 0.0063% from a very good sine wave generator. The green trace is 0.1034% from a cheaper unit. The number of harmonics set for measurement was 20 although 200 is possible! Bottom traces are the sine wave time record simultaneously obtained from both units

ID1 real-time octave measurement.
UK4 microphone adapter and power supply
ID2 swept sine measurements (has a dynamic range of 130dB)
ID3 curve fit and synthesis
ID4 arbitrary waveform source
IC2 Instrument Basic

Our 2-channel instrument had all of the options fitted except Instrument basic which allows you to develop a custom user-interface, integrate several instruments and peripherals into a system using the 35670A as the system controller and to automate measurements. These can be added retrospectively as can all the other options if desired.

This option would be really useful because there are a lot of buttons to press for each setup and it is easy to make a mistake.

There are large volumes of instrument and service manuals and application notes provided by Agilent and very good explanations of the theories behind all the more complicated tests.

The online HELP menu is particularly useful as it gives full screen instructions of the functions of the last button press.

It's a rugged unit able to withstand extremes of temperature (0-55°C), altitude (4600 metres) and shock (up to 10G!!).

Although it weighs in at 15kg it remains a very compact and portable unit well suited for applications in the field, especially since it can operate

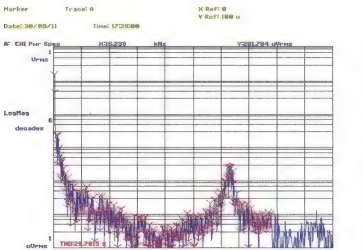


Fig.5 mains harmonics are displayed to 25kHz and a peak of 16.38kHz is displayed. THD figure is incorrect because of "aliasing" errors and the "zoom" should be used for accuracy, nevertheless we included this trace to show how much rubbish is on our powerlines!

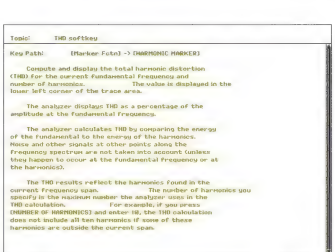


Fig.6 when the "help" key is pressed directly after the "harmonic marker" key you get to view an excellent set of instructions so you will never get lost!

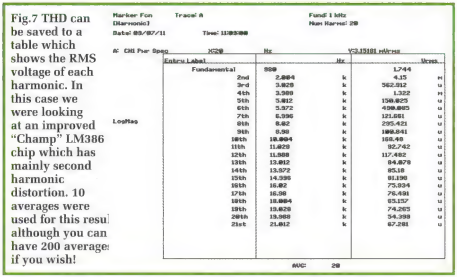


Fig.7 THD can be saved to a table which shows the RMS voltage of each harmonic. In this case we were looking at an improved "Champ" LM386 chip which has mainly second harmonic distortion. 10 averages were used for this resu although you can have 200 average if you wish!

from 12-28V DC as well as from 90-264VAC.

At the back of the instrument there is a BNC socket for the source signals, external trigger and tachometer input, capable of handling 42V peak, so you can read RPM without any signal conditioning (such as a micro switch or solenoid)

There is also the power select switch which switches between AC and DC power sources without interrupting operation and is protected from accidental switching.

There is a parallel port and a serial port for printers (sorry, no USB) and also a keyboard socket to accommodate a standard PC keyboard, which allows you to add captions and control the instrument.

There is an HPIB (Hewlett-Packard Interface Bus) connector which can be used for controlling and programming the instrument using an appropriate interface or linking it to other instrument equipped with HPIB (or GPIB – General Purpose Interface Bus).

There has been quite a bit of discussion on the internet about saving traces to files but we used the National Instruments GPIB-USB converter to download traces into a notebook computer using John Miles's excellent (free) HP7470A emulator software.

This allows you to download traces in colour, change colours and add captions and save then print or save as PDF files.

It's a much better option than printing from the serial port which is only in monochrome.

If you need to do this, go to the website www.ke5fx.com/gpib/7470.htm and you will find that you can do this for a whole raft of HP, Tektronix & Rohde & Schwarz spectrum analysers

The front of the instrument has 21 "hard keys" which are fairly self explanatory and eight "soft keys" labelled preset, help, basic, HPIB/local, utility, plot/print and save/recall.

Our instrument has two BNC inputs and one output for source signals (duplicated at the back).

The system uses a 3.5 inch floppy which stores instrument states, programs, time captured data, waterfall data, trace data, limits, math functions, data tables, and curve fit/synthesis tables.

Supported disk formats are HP-LIF and MS-DOS. Internal RAM on our device was 8Mb, which appears to be more than enough for most purposes.

One of the nice features is the super-quiet fan which you can only hear in extremely quiet environments. There is provision to turn it off for short periods while the instrument is running, so as not to interfere with sensitive loudspeaker tests. But at a quoted output of <45dB it is almost impossible to hear the difference! It is without doubt a very quiet instrument.

Now we come to one of the most unpopular features of this device – the external monitor output socket. This is a DE9 9-pin socket which does not fit any modern external monitor.

Not only that but even if you use a converter to a 15-pin socket, the monitor will not work, because it requires multi-sync monitor which may now be difficult to obtain.

Agilent has devoted a fair amount of time on this issue and details for selecting and fitting suitable monitors can be found at:

www.home.agilent.com/agilent/editorial.jspx?cc=AU&lc=eng&ckey=490434&nid=-11143.0.00&id=490434&pselect=SR.GENERAL

Measurements

There are five basic measurement types that can be performed:

1: Measuring Rotating Machinery

This involves connecting & calibrating transducers and measuring vibration power, characterising tachometer signals and measuring an order spectrum.

An RPM stepped order map can be set up to observe, for example, what happens as a motor increases its speed.

Using proximity sensors and orbital diagrams, it is also possible to identify problems such as bent shafts or eccentric rotation.

Key Specifications

Frequency range:	(1 channel) 195.3mHz to 102.4kHz (2 channel) 97.7mHz to 51.2kHz (4 channel) 48.8mHz to 25.6kHz
Lines of resolution:	100, 200, 400, 800 and 1600 lines of resolution
Dynamic range:	90dB (130dB in swept-sine mode)
Accuracy:	±0.15dB
Maximum input:	42V peak
Source:	Random, Burst Random, Periodic Chirp, Burst Chirp, Pink Noise, Sine, Arbitrary Waveform
Maximum output:	±5V peak (AC)
Measurements:	Linear, Cross, and Power Spectrum, Power Spectral Density, Frequency Response, Coherence, THD to 0.0015%, Phase Distortion, Harmonic Power, Time Waveform, Auto-correlation, Cross-Correlation, Histogram, Polar Display, Octave analysis with triggered waterfall display Tachometer input and order tracking with orbit diagram
Engineering units:	g, m/s^2, m/s, m, in/s^2, in/s, in, mil, kg, dyne, lb, N, and pascals

One of the major advantages of the 35670A is that it can operate from AC and DC, making it highly versatile and one of the few instruments that can swap from the laboratory to the field (including mobile use) with ease. Here it is being used in a motor vehicle where a range of parameters can be recorded for later analysis.

2: Measuring Structures

All structures have natural frequencies of resonance – as some very large bridge builders have found to their horror.

The frequency response function measures the input excitation and output response simultaneously.

To find natural frequencies, an impulse response measurement can be performed on the structure and the Agilent 35670A can be used to compute the frequency response.

An instrumented hammer impacts the structure and an accelerometer measures the response.

The impact hammer has a load cell that measures the level of force during the impact.

Basically, bigger hammers are required for bigger structures and various methods can be used to finely tune the instrument to obtain reliable results.

Because it is such a transient test, it is best to first look at a time trace of the excitation (like an oscilloscope record) and setting the instrument amplitude ranges to avoid clipping during the frequency response evaluation.

This method would be useful in evaluating speaker enclosures and room vibrations too.

3: Measuring Sound

Using the microphone adapter which screws on to the bottom of the 35670A, with a 4-channel instrument it is possible to attach and calibrate up to four microphones and also provide them with phantom power up to 200V DC.

This will allow measurements of sound pressure levels (SPLs) and impulses and real time 1/3 or 1/12 octave measurements. You can also view frequency response and impulses over time with the waterfall function and obtain a time record.

4: Measuring Spectra and Networks

This involves measuring wideband and narrowband spectra, frequency and amplitude, noise power, harmonic distortion and sideband power.

Frequency response can be measured using FFT (includes phase measurement) or swept sine. The latter is more accurate for frequencies lower than 100Hz.

Spectral maps can also be generated, phase distortion calculated and displayed as microsecond delay vs frequency.

5: Measuring Control Systems

Performance, step response, stability, loop response, gain and phase margins can all be measured with this instrument.

Also of interest is the ability to generate Nyquist diagrams for evaluating various control systems such as servo systems.

The control loop may be composed of mechanical devices and/or analog, digital or electrical elements.

Drawbacks

There is no doubt the 35670A has already become an industry standard for those applications mentioned above.

In fact, many industry and even government department and organisation tenders and contracts specifically call for the 35670A as part of their validation, quality control and testing procedures. As such, it has become *de rigeur* in many standards – to replace it would call for massive re-writes (and therefore costs).

However, the popularity of the device should be reason enough for a long-overdue upgrade, such as faster processing times, better and more user-friendly programming, USB connectivity, external monitoring, pre-programmed setups and better displays.

This should be relatively easy for Agilent to undertake.

Perhaps because the instrument has such a monopoly on low and ultra low frequency analysis that it has little to compete against and has generated a culture of "its good enough!"

Conclusion

With the rare ability to accurately evaluate low frequencies, the instrument is at the opposite end of the ever-growing high frequency range of spectrum analysers where there are many manufacturers fighting to demonstrate they have the best devices for upwards of 100GHz.

But, in a way this has kept the Agilent 35670A in the doldrums of development.

The fact that it has survived for so long demonstrates that it is an excellent and well-respected instrument.

Current users are largely happy to put up with the drawbacks because they feel familiar with its controls and all their standards are based on it.

It will probably continue to be manufactured for some years to come but it would be nice to see some of those long-overdue improvements. SC

Where from?

The Agilent 35670A Dynamic Signal Analyser and its extensive range of options/accessories is available from Agilent Technologies Australia Pty Ltd, 679 Springvale Road, Mulgrave Vic 3170; Tel (03) 9560-7133, Fax: (03) 9560-7950.

The company's international website is www.agilent.com, from where you can specify your country.

SILICON CHIP REFERENCE BOOKSHOP

Save 10% WANT TO SAVE 10%? SILICON CHIP (PRINT EDITION) SUBSCRIBERS* AUTOMATICALLY QUALIFY FOR A 10% DISCOUNT ON ALL BOOK PURCHASES! (*Does not apply to website orders)

PROGRAMMING and CUSTOMIZING THE PICAXE By David Lincoln (2nd Ed, 2011) $65.00

A great aid when wrestling with applications for the PICAXE series of microcontrollers, at beginner, intermediate and advanced levels. Every electronics class, school and library should have a copy, along with anyone who works with PICAXEs. 300 pages in paperback

See Review April 2011

PIC IN PRACTICE

by D W Smith. 2nd Edition - published 2006 $60.00

Based on popular short courses on the PIC, for professionals, students and teachers. Can be used at a variety of levels. An ideal introduction to the world of microcontrollers. 255 pages in paperback.

PIC MICROCONTROLLER – your personal introductory course By John Morton 3rd edition 2005. $60.00

A unique and practical guide to getting up and running with the PIC. It assumes no knowledge of microcontrollers – ideal introduction for students, teachers, technicians and electronics enthusiasts. Revised 3rd edition focuses entirely on re-programmable flash PICs such as 16F54, 16F84 12F508 and 12F675. 226 pages in paperback.

OP AMPS FOR EVERYONE

By Carter & Mancini – 3RD EDITION $100.00

Substantially updates coverage for low-speed and high-speed applications, and provides step-by-step walk-throughs for design and selection of op amps. Huge 648 pages!

PROGRAMMING 32-bit MICROCONTROLLERS IN C By Luci di Jasio (2008) $79.00

Subtitled Exploring the PIC32, a Microchip insider tells all on this powerful PIC! Focuses on examples and exercises that show how to solve common, real-world design problems quickly. Includes handy checklists. FREE CD-ROM includes source code in C, the Microchip C30 compiler, and MPLAB SIM. 400 pages paperback.

PIC MICROCONTROLLERS: know it all

Multiple authors $83.00

The best of subjects Newnes authors have written over the past few years, combined in a one-stop maxi reference. Covers introduction to PICs and their programming in Assembly, PICBASIC, MBASIC & C. 900+ pages in paperback.

USING UBUNTU LINUX

by J Rolfe & A Edney – published 2007 $27.00

Ubuntu Linux is a free and easy-to-use operating system, a viable alternative to Windows and Mac OS. Introduces Ubuntu, tells how to set it up, covers the various Open Office applications and gives troubleshooting hints and tips. Highly recommended. 222 pages in paperback

DVD PLAYERS AND DRIVES

by K.F. Ibrahim. Published 2003. $71.00

A guide to DVD technology and applications, with particular focus on design issues and pitfalls, maintenance and repair. Ideal for engineers, technicians, students of consumer electronics and sales and installation staff. 319 pages in paperback.

See Review Feb 2004

ELECTRIC MOTORS AND DRIVES

By Austin Hughes - Third edition 2006 $51.00

Intended for non-specialist users of electric motors and drives, filling the gap between academic texts and general "handbooks". Explores all of the widely-used modern types of motor and drive including conventional & brushless DC, induction motors, steppers, servos, synchronous and reluctance. 384 pages, soft cover.

AC MACHINES

By Jim Lowe Published 2006 $66.00

Applicable to Australian trades-level courses including NE10 AC Machines, NE12 Synchronous Machines and the AC part of NE30 Electric Motor Control and Protection. Covering polyphase induction motors, single-phase motors, synchronous machines and polyphase motor starting. 160 pages in paperback.

SELF ON AUDIO

by Douglas Self 2nd Edition 2006 $69.00

A collection of 35 classic magazine articles offering a dependable methodology for designing audio power amplifiers to improve performance at every point without significantly increasing cost. Includes compressors/limiters, hybrid bipolar/FET amps, electronic switching and more. 474 pages in paperback.

SMALL SIGNAL AUDIO DESIGN

By Douglas Self – First Edition 2010 $88.00

The latest from the Guru of audio. Explains audio concepts in easy-to-understand language with plenty of examples and reasoning. Inspiration for audio designers, superb background for audio enthusiasts and especially where it comes to component peculiarities and limitations. Expensive? Yes. Value for money? YES! Highly recommended. 558 pages in paperback.

AUDIO POWER AMPLIFIER DESIGN HANDBOOK

by Douglas Self – 5th Edition 2009 $81.00

"The Bible" on audio power amplifiers. Many revisions and updates to the previous edition and now has an extra three chapters covering Class XD, Power Amp Input Systems and Input Processing and Auxiliarly Subsystems. Not cheap and not a book for the beginner but if you want the best reference on Audio Power Amps, you want this one! 463 pages in paperback.

See Review March 2010

PRACTICAL GUIDE TO SATELLITE TV

By Garry Cratt – Latest (7th) Edition 2008 $49.00

Written in Australia, for Australian conditions by one of Australia's foremost satellite TV experts. If there is anything you wanted to know about setting up a satellite TV system, (including what you can't do!) it's sure to be covered in this 176-page paperback book.

NEWNES GUIDE TO TV & VIDEO TECHNOLOGY

By KF Ibrahim 4th Edition (Published 2007) $49.00

It's back! Provides a full and comprehensive coverage of video and television technology including HDTV and DVD. Starts with fundamentals so is ideal for students but covers in-depth technologies such as Blu-ray, DLP, Digital TV, etc so is also perfect for engineers. 600+ pages in paperback.

RF CIRCUIT DESIGN

by Chris Bowick, Second Edition, 2008. $63.00

The classic RF circuit design book. RF circuit design is now more important that ever in the wireless world. In most of the wireless devices that we use there is an RF component – this book tells how to design and integrate in a very practical fashion. 244 pages in paperback.

SWITCHING POWER SUPPLIES A-Z

by Sanjaya Maniktala, Published April 2012. $83.00

Thoroughly revised! The most comprehensive study available of theoretical and practical aspects of controlling and measuring EMI in switching power supplies.

NEW 2012 EDITION

PRACTICAL RF HANDBOOK

by Ian Hickman. 4th edition 2006 $61.00

A guide to RF design for engineers, technicians, students and enthusiasts. Covers key topics in RF: analog design principles, transmission lines, couplers, transformers, amplifiers, oscillators, modulation, transmitters and receivers, propagation and antennas. 279 pages in paperback.

PRACTICAL VARIABLE SPEED DRIVES & POWER ELECTRONICS

by Malcolm Barnes. 1st Ed, Feb 2003. $73.00

An essential reference for engineers and anyone who wishes to design or use variable speed drives for induction motors. 286 pages in soft cover.

See Review Feb 2003

BUILD YOUR OWN ELECTRIC MOTORCYCLE

by Carl Vogel. Published 2009. $40.00

Alternative fuel expert Carl Vogel gives you a hands-on guide with the latest technical information and easy-to-follow instructions for building a two-wheeled electric vehicle – from a streamlined scooter to a full-sized motorcycle. 384 pages in soft cover.

NOTE: ALL PRICES ARE PLUS P&P – AUSTRALIA ONLY: $10.00 per order; NZ – $12.00 PER BOOK; REST OF WORLD $18.00 PER BOOK

To Place Your Order:	eMAIL (24/7)	OR	FAX (24/7)	OR	PAYPAL (24/7)	OR	PHONE - (9-5, Mon-Fri)	OR	MAIL
	silicon@siliconchip.com.au with order & credit card details		Your order and card details to (02) 9939 2648 with all details		Use your PayPal account silicon@siliconchip.com.au		Call (02) 9939 3295 with your credit card details		Your order to PO Box 139 Collaroy NSW 2097

Or use the handy order form on P87 of this issue

*ALL TITLES SUBJECT TO AVAILABILITY. PRICES VALID FOR MONTH OF MAGAZINE ISSUE ONLY. ALL PRICES INCLUDE GST

The bad news: It's Tax Time!
The good news: Subscribe to SILICON CHIP before June 30 and you can claim your tax deduction THIS YEAR!

If your business is electronics – whatever the level, from apprentice to PhD – the chances are your subscription to SILICON CHIP is 100% tax deductible (check with your accountant).

So why not let the tax man pick up part of your subscription – it's better than getting something for nothing. It's getting something BACK from the tax man!

But you have to hurry: you MUST lodge your subscription order by JUNE 30 in order to claim your deduction THIS FINANCIAL YEAR. Don't wait: do it today!

PLUS! There are some BIG ADVANTAGES in subscribing . . .

1. It's cheaper – you $ave money!
2. It's delivered right to your mail box!!
3. You can always be sure you'll receive it!!!
4. We pick up all the postage and handling charges!!!!
5. You will never miss an issue because it's sold out (or you forgot)!!!!!
6. You choose the length of subscription required: 6, 12 or 24 months.
7. You can even choose to auto-renew your subscription at the end of the period!

PRICE OF 12 ISSUES OVER-THE-COUNTER IN AUSTRALIA: ~~$111.60~~

Here's the deal:

6 months *SILICON CHIP*: $52.00 in Australia; $AU55.00 in NZ*; $AU80.00 o'seas*

12 Months *SILICON CHIP*: $97.50 in Australia; $AU99.00 in NZ*; $AU140.00 o'seas*

24 Months *SILICON CHIP*: $188.00 in Australia; $AU196.00 in NZ*; $AU265.00 o'seas* VIA AIR MAIL

There's a handy order form on P97

Vintage Radio

By Rodney Champness, VK3UG

John de Haas and his Philips collection

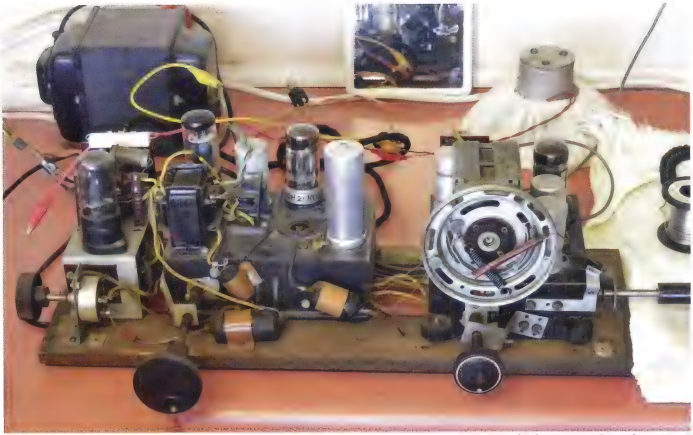
This month, we take a look at a vintage radio collection belonging to enthusiast John de Haas. Philips receivers made in both Europe and Australia feature prominently in his collection and although some models look identical, the chassis used can be quite different.

IT'S ALWAYS INTERESTING to find out how fellow vintage radio collectors became involved in the hobby and started their collections. In some cases, it's because they worked in radio or electronics as technicians and adopted the hobby as a natural extension of their professional expertise. On the other hand, many collectors had no interest in vintage radio until some incident sparked their curiosity.

In my case, it began when I was invited to a meeting of vintage radio enthusiasts, which I reluctantly agreed to attend. My interest at that stage was only lukewarm and I was really only interested in portable WWII military equipment. In short, I only wanted to deal with "real" radios such as complex military radio transceivers but after a few meetings, I very quickly became interested in collecting and restoring domestic radios.

One fellow enthusiast, John de Haas, has some rather special Philips receivers among his collection, many of them originating from Europe. His background is equally as interesting.

John's introduction to vintage radio occurred back in 2003 when he was involved in winding up his late mother's estate in Holland. Amongst the items left to him was a rather nice-looking



This view shows the three-part aluminium and Bakelite chassis of a Sierra 159X receiver which is currently undergoing restoration on John's workbench.

Philips BX480A table receiver which was manufactured in 1939 (it's shown in one of the photos). The receiver had a lot of appeal and a great deal of sentimental value, so he decided to bring it back to Australia.

John carefully packed the set so that it would not be damaged on the long journey but when it arrived, the cabinet had shattered into many pieces, the chassis was bent and several valves had broken. It was a huge disappointment and an indictment of the care taken by freight agents.

After getting over his initial shock, John resolved that he would completely rebuild the receiver. And so the box of pieces was left on a shelf in the garage for a year until he eventually mustered the enthusiasm to start the mammoth job.

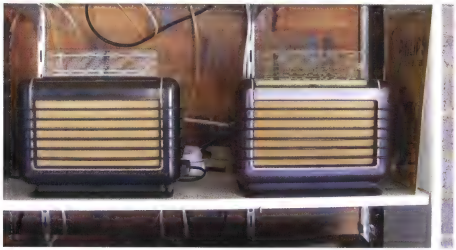
The challenge now was to turn the broken parts back into a recognisable receiver. John started with the cabinet and over the next four months, carefully glued the various pieces back together using two-part Araldite. These pieces were held together while the glue dried using Glad-Wrap covered boards and C-clamps, to ensure flat surfaces.

Despite being badly damaged in transit, this 1939 Philips BX480A has now been restored to full working order. The restoration included extensive cabinet repairs and the manufacture of a new glass dial-scale.

Eventually, the Bakelite cabinet was back in one piece but the glued joints looked terrible so it needed painting. And so, after a thorough sanding, the cabinet was spray painted good old Mission Brown. As John points out, it now looks OK but it's no longer original which is a pity.

The dial scale was broken into many pieces too and it took John many hours of patient work to make a new one. In fact, repairing and making dial-scales is a task that John has well and truly mastered. He has since reproduced

The Philips Sierra model H283 (left) and its Australian Philips equivalent. The cabinets are identical, although different dial scales are used to suit the intended market.



Another set of Philips twins, this time showing the Dutch model 209U and the visually identical Australian model 112 at right. Note the "pop-up" dial scales.

Also in John's collection is this magnificent Graetz Sinfonia Model 422 5-band table receiver. The 30cm ruler at the left gives an indication of the set's size.

dial scales for several of his other sets and they are virtually indistinguishable from the original items.

In fact, his technique for reproducing dial-scales may form part of an article later on. His method is quite practical but like many such undertakings, it does take time to do.

Restoring the circuit

Apart from the broken valves, the electronic components were largely unaffected by the rough treatment during the set's trip to Australia. However, quite a lot of work was required to restore the chassis. For example, in order to straighten the chassis, all items attached to it had to be first removed before it could be hammered back into shape. The various parts were then refitted.

This was quite a job and the set now looks quite good from the outside. However, it still bears the scars of its mistreatment inside the cabinet and under the chassis.

John's restoration of his mother's set back in 2003 kick-started his interest in vintage radio. And because John has connections with both Europe and Australia, it was logical that he would collect radios from both regions.

Because of his Dutch background, John has a liking for Philips receivers and these feature prominently in his collection. One particular feature of his collection are several Dutch and Australian Philips designs which have identical cabinets but different chassis.

John's background

John's parents were with the Colonial Service of the Dutch Government. He was born in Indonesia in 1935 and subsequently migrated to Australia from Holland in 1957 at the age of 22. Both he and his wife Harriet now regularly travel back to Holland to visit friends and relatives.

While there, he often visits the various vintage radio groups (John is a member of the NVHR, the Dutch equivalent of our HRSA). During these visits, he sometimes finds a vintage European set that catches his eye and brings it back to Australia.

John tells me that in a previous life, before retirement, he worked as a mechanical engineer in mining and construction. He retired from BHP in 1992 and then worked as a freelance Maintenance Management Consultant

This photo shows the Dutch Philips BX462A at left and the Australian Philips 115 at right. Although visually identical apart from the pop-up dial scales, their chassis are quite different as the photo below shows.

in Australia, India and Indonesia up until 2000.

His interest in valve radios actually dates back to his younger days in Holland. He built radios and amplifiers as a hobby during the immediate post-war years but subsequently lost interest in the 1960s with the advent of the transistor and integrated circuit technology. As stated, it was the restoration of his mother's old radio that rekindled his interest in valve technology.

As well as being a member of the HRSA and the NVHR, John is also a member of the South East Queensland Vintage Radio Club and the Vintage Radio Club of North East Victoria. In fact, he joined these organisations not long after the successful restoration of his mother's set. Club membership is important to vintage radio collectors, particularly when it comes technical advice and backup and help with obtaining hard-to-get parts.

The Australian Philips 115 and the Dutch Philips BX462A from the rear, with their backs removed. The differences between the two chassis are quite marked.

John's collection

During the last nine years, John has restored many quite elaborate European radios, particularly Philips sets. He has also restored a number of Australian sets, along with one Canadian receiver and a mantel receiver from New Zealand. At last count, there were over 50 restored radios in his collection, so he has added about of six receivers to his collection each year. Most of these sets are in full working order.

In all, there are about 30 European sets in the collection. These range from quite simple four and 5-valve AC/DC mantel receivers to quite elaborate receivers boasting long wave, medium wave and one or more shortwave bands plus the 88-108MHz FM band. Some of these receivers feature upwards of 12 valves.

The Australian sets are standard mantel and table-model receivers, many of which have been described in Vintage Radio over the years. The lone New Zealand set is a Philco, while the Canadian set is a Motorola.

The top-of-the-line receivers all have attractive, large wooden cabinets, while those a little further down the pecking order have large, good-quality Bakelite cabinets. The simpler, cheaper models either have small Bakelite or plastic cabinets.

John's collection is neatly arranged along a number of shelves in his garage, with one of his vehicles relegated to a spot outside. The sets are all permanently connected to power and are each fitted with a short antenna so that they can be operated on a regular basis.

One interesting aspect of the collection is a group of eight Philips receivers arranged in four pairs of apparently

More Philips "twins" – the Australian model 138 is shown at top, while below it is the almost visually-identical Dutch BX221U.

identical units. However, on close inspection, the pairs of receivers are not identical at all. In each case, one receiver is of Dutch manufacture and the other is Australian made.

Apparently, copies of the respective cabinet moulds were sent to Australia from the Philips parent company in Eindhoven, Holland. The resulting locally-produced cabinets were then each used to house different Australian-designed chassis. It will be interesting to compare the circuits, performance, layout and facilities of each of these pairs at a later date.

John's large table radios, such as the Graetz Sinfonia 422 5-band receiver and the Philips BX653A 5-band 12-valve receiver, are big, powerful units with impressive performance. But although these are magnificent receivers, they are far from easy to service and a service manual and plenty of time are needed to ensure a successful restoration.

The mantel receivers in the display were made by most of the major manufacturers in Australia, with a sprinkling of overseas brands. These are receivers that Australian collectors are more familiar with, particularly when it comes to fault-finding and restoration.

John's workshop

John has a spacious workbench for doing electronic and basic mechanical work on his radios. Alignment and sensitivity adjustments are carried out with the aid of a Philips GM2883 signal generator. This is a step up from a basic signal generator such as the Leader LSG10 and LSG11. A Philips GM6001 valve voltmeter is used for voltage and current measurements, along with a digital multimeter.

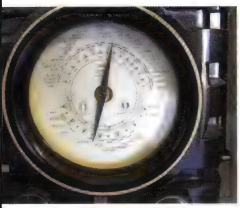
Also included in the test-gear line-up are two variable power supplies which can substitute for the internal power supplies of most receivers. In addition, a Variac is used to test the performance of receivers across the normal mains voltage range. This is a very handy test which will often bring to light voltage-sensitive faults.

Other equipment includes an adjustable lampholder plus a supply of jumper leads which are stored at the back of the workbench. These leads make it easy to attach meters to a circuit so that various operating conditions can be observed, eg, while alignment adjustments are made.

Another workbench is used for some of the larger mechanical work. During my visit, a speaker cloth was being glued to a frame and this was held in place with several clamps. And talking about speaker cloth, John's wife Harriet hand-wove open-mesh speaker cloth for several of the receivers in his collection.

A number of small trays and drawers containing various components are mounted behind the main workbench, while larger parts are stored against one of the garage walls. John also has

John's NZ-made La Gloria Philco mantel receiver.



The 3-band Philips BX373A receiver features a dial that's styled to look like a compass.

a good supply of valves, which are used as necessary. However, according to John, many of the old radios he has restored didn't require replacement valves and only rarely was more than one required.

Some useful tips

Based on their experience, most vintage radio collectors come up with ideas to help make restoration jobs easier and John is certainly no different in this regard.

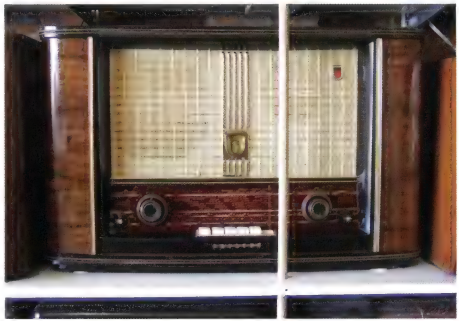
One of his useful tips is to use aluminium foil patty pans (available from supermarkets) to keep components together when a set is dismantled. These are ideal for storing the many nuts, bolts, screws, knobs and other parts that may be removed from a receiver during restoration.

Good organisation is important when is comes to restoring a vintage radio. There is nothing worse than not keeping the bits and pieces together and then finding that some vital item is missing somewhere in the workshop.

Restringing dial-drive systems is something that many vintage radio restorers would rather not have to do. The larger European sets in particular often have extremely complex dial-drives and other remote control mechanisms. As a result, it's important to try to obtain a diagram of the layout, as some are quite difficult to figure out from scratch.

John therefore tries to obtain a manual for any set that's being worked on and he photographs the dial-drive system before he working on it. This approach is particularly important with the more complex receivers such as the Graetz Sinfonia 422, the Philips BX653A and sets like the AWA 7-band series of radios. Conversely, sets using handspan dials are so simple that no diagram is necessary.

John de Hass with his vintage radio receiver collection. He's been collecting and restoring vintage receivers for around nine years.



The Philips BX653A 5-band twin-amplifier table receiver is a large, powerful unit with no less than 12 valves. A service manual and plenty of time were necessary to complete the restoration of this magnificent receiver.

Summary

As can be seen, John has quite a wide variety of receivers from both Europe and elsewhere and he has done an excellent job restoring them to full working order. This is particularly evident with the larger European models. The workshop is very functional and most problems can be diagnosed and fixed using his existing equipment and spare parts.

As to which sets John prefers, the Dutch Philips receivers are favourites, particularly when it comes to appearance. However, he also says that the European sets are more difficult to service, with bits and pieces scattered everywhere inside them. So for ease of service, he definitely prefers the Australian sets. SC

SILICON CHIP PARTSHOP

Looking for a specialised component to build that latest and greatest *SILICON CHIP* project? Maybe it's the PCB you're after. Or a pre-programmed micro. Or some other hard-to-get "bit". The chances are they are available direct from the *SILICON CHIP* **PARTSHOP**.

As a service to readers, *SILICON CHIP* has established the **PARTSHOP**. No, we're not going into opposition with your normal suppliers – this is a direct response to requests from readers who have found difficulty in obtaining specialised parts.

- **PCBs nominated are normally IN STOCK and ready for despatch (you don't have to wait for them to be made!).**
- **Even if stock runs out (eg, for high demand), in most cases there will be no longer than a two-week wait.**
- **One low p&p charge: $10 per order, regardless of how many boards you order! (Australia only; overseas clients – email us for a postage quote).**
- **New project boards will normally be available within days of the magazine on-sale date: no waiting!**
- **Our PCBs are beautifully made, very high quality fibreglass boards with pre-tinned tracks, silk screen overlays and where applicable, solder masks.**
- **Best of all, those boards with fancy cut-outs or edges are already cut out to the *SILICON CHIP* specifications – no messy blade work required!**

PROJECT	PUBLISHED	CODE	Price*
AM RADIO TRANSMITTER	JAN 1993	06112921	$25.00
CHAMP: SINGLE CHIP AUDIO AMPLIFIER	FEB 1994	01102941	$5.00
PRECHAMP: 2-TRANSISTOR PREAMPLIER	JUL 1994	01107941	$5.00
HEAT CONTROLLER	JULY 1998	10307981	$25.00
MINIMITTER FM STEREO TRANSMITTER	APR 2001	06104011	$25.00
MICROMITTER FM STEREO TRANSMITTER	DEC 2002	06112021	$10.00
SMART SLAVE FLASH TRIGGER	JUL 2003	13107031	$10.00
12AX7 VALVE AUDIO PREAMPLIFIER	NOV 2003	01111031	$25.00
POOR MAN'S METAL LOCATOR	MAY 2004	04105041	$10.00
BALANCED MICROPHONE PREAMP	AUG 2004	01108041	$25.00
LITTLE JIM AM TRANSMITTER	JAN 2006	06101062	$25.00
POCKET TENS UNIT	JAN 2006	11101061	$25.00
STUDIO SERIES RC MODULE	APRIL 2006	01104061	$25.00
ULTRASONIC EAVESDROPPER	AUG 2006	01208061	$25.00
RIAA PREAMPLIFIER	AUG 2006	01108061	$25.00
GPS FREQUENCY REFERENCE (A) (IMPROVED)	MAR 2007	04103073	$55.00
GPS FREQUENCY REFERENCE DISPLAY (B)	MAR 2007	04109073	$35.00
KNOCK DETECTOR	JUNE 2007	05106071	$25.00
SPEAKER PROTECTION AND MUTING MODULE	JULY 2007	01207071	$25.00
CDI MODULE SMALL PETROL MOTORS	MAY 2008	05105081	$15.00
LED/LAMP FLASHER	SEP 2008	11009081	$10.00
12V SPEED CONTROLLER/DIMMER *(Use Hot Wire Cutter PCB from Dec2010 18112101)*			$25.00
CAR SCROLLING DISPLAY	DEC 2008	05101092	$25.00
USB-SENSING MAINS POWER SWITCH	JAN 2009	10101091	$45.00
DIGITAL AUDIO MILLIVOLTMETER	MAR 2009	04103091	$35.00
INTELLIGENT REMOTE-CONTROLLED DIMMER	APR 2009	10104091	$10.00
INPUT ATTENUATOR FOR DIG. AUDIO M'VOLTMETER	MAY 2009	04205091	$10.00
6-DIGIT GPS CLOCK	MAY 2009	04105091	$35.00
6-DIGIT GPS CLOCK DRIVER	JUNE 2009	07106091	$25.00
UHF ROLLING CODE TX	AUG 2009	15008091	$10.00
UHF ROLLING CODE RECEIVER	AUG 2009	15008092	$45.00
6-DIGIT GPS CLOCK AUTODIM ADD-ON	SEPT 2009	04208091	$10.00
STEREO DAC BALANCED OUTPUT BOARD	JAN 2010	01101101	$25.00
DIGITAL INSULATION METER	JUN 2010	04106101	$25.00
ELECTROLYTIC CAPACITOR REFORMER	AUG 2010	04108101	$55.00
ULTRASONIC ANTI-FOULING FOR BOATS	SEP 2010	04109101	$25.00
HEARING LOOP RECEIVER	SEP 2010	01209101	$25.00
S/PDIF/COAX TO TOSLINK CONVERTER	OCT 2010	01210101	$10.00
TOSLINK TO S/PDIF/COAX CONVERTER	OCT 2010	01210102	$10.00
DIGITAL LIGHTING CONTROLLER SLAVE UNIT	OCT 2010	16110102	$45.00
HEARING LOOP TESTER/LEVEL METER	NOV 2010	01111102	$25.00
UNIVERSAL USB DATA LOGGER	DEC 2010	04112101	$25.00
HOT WIRE CUTTER CONTROLLER	DEC 2010	18112101	$25.00
433MHZ SNIFFER	JAN 2011	06101111	$10.00
CRANIAL ELECTRICAL STIMULATION	JAN 2011	99101111	$30.00
HEARING LOOP SIGNAL CONDITIONER	JAN 2011	01101111	$30.00
LED DAZZLER	FEB 2011	16102111	$25.00
12/24V 3-STAGE MPPT SOLAR CHARGER	FEB 2011	14102111	$15.00
SIMPLE CHEAP 433MHZ LOCATOR	FEB 2011	06102111	$5.00
THE MAXIMITE	MAR 2011	06103111	$25.00
UNIVERSAL VOLTAGE REGULATOR	MAR 2011	18103111	$15.00
12V 20-120W SOLAR PANEL SIMULATOR	MAR 2011	04103111	$25.00
MICROPHONE NECK LOOP COUPLER	MAR 2011	01209101	$25.00
PORTABLE STEREO HEADPHONE AMP	APRIL 2011	01104111	$25.00
CHEAP 100V SPEAKER/LINE CHECKER	APRIL 2011	04104111	$25.00
PROJECTOR SPEED CONTROLLER	APRIL 2011	13104111	$10.00
SPORTSYNC AUDIO DELAY	MAY 2011	01105111	$30.00

PROJECT	PUBLISHED	CODE	Price*
100W DC-DC CONVERTER	MAY 2011	11105111	$25.00
PHONE LINE POLARITY CHECKER	MAY 2011	12105111	$10.00
20A 12/24V DC MOTOR SPEED CONTROLLER MK2	JUNE 2011	11106111	$25.00
USB STEREO RECORD/PLAYBACK	JUNE 2011	07106111	$25.00
VERSATIMER/SWITCH	JUNE 2011	19106111	$25.00
USB BREAKOUT BOX	JUNE 2011	04106111	$10.00
ULTRA-LD MK3 200W AMP MODULE	JULY 2011	01107111	$25.00
PORTABLE LIGHTNING DETECTOR	JULY 2011	04107111	$25.00
RUDDER INDICATOR FOR POWER BOATS (4 PCBs)	JULY 2011	20107111-4	$80 per set
VOX	JULY 2011	01207111	$25.00
ELECTRONIC STETHOSCOPE	AUG 2011	01108111	$25.00
DIGITAL SPIRIT LEVEL/INCLINOMETER	AUG 2011	04108111	$15.00
ULTRASONIC WATER TANK METER	SEP 2011	04109111	$25.00
ULTRA-LD MK2 AMPLIFIER UPGRADE	SEP 2011	01209111	$5.00
ULTRA-LD MK3 AMPLIFIER POWER SUPPLY	SEP 2011	01109111	$25.00
HIFI STEREO HEADPHONE AMPLIFIER	SEP 2011	01309111	$45.00
GPS FREQUENCY REFERENCE (IMPROVED)	SEP 2011	04109073	$55.00
DIGITAL LIGHTING CONTROLLER LED SLAVE	OCT 2011	16110111	$30.00
USB MIDIMATE	OCT 2011	23110111	$30.00
QUIZZICAL QUIZ GAME	OCT 2011	08110111	$30.00
ULTRA-LD MK3 PREAMP & REMOTE VOL CONTROL	NOV 2011	01111111	$35.00
ULTRA-LD MK3 INPUT SWITCHING MODUL	NOV 2011	01111112	$25.00
ULTRA-LD MK3 SWITCH MODULE	NOV 2011	01111113	$10.00
ZENER DIODE TESTER	NOV 2011	04111111	$20.00
MINIMAXIMITE	NOV 2011	07111111	$10.00
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	18112111	$5.00
DIGITAL AUDIO DELAY	DEC 2011	01212111	$30.00
DIGITAL AUDIO DELAY FRONT & REAR PANELS	DEC 2011	01211112P2/3	$20 per set
AM RADIO	JAN 2012	06101121	$10.00
STEREO AUDIO COMPRESSOR	JAN 2012	01201121	$30.00
STEREO AUDIO COMPRESSOR FRONT & REAR PANELS	JAN 2012	01201121P1/2	$20.00
3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS)	JAN 2012	01101121/2	$30 per set
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
SEMTEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMTEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMTEST FRONT PANEL	MAR 2012	04103123	$75.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT START SUPPRESSOR	APR 2012	10104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04105121	$30.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04105122	$20.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER	APR 2012	10105121	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER F&R PANELS	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$30.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08109121	$10.00

Other items currently in the PartShop: — * **All prices P&P – $10 Per order within Australia.**

G-FORCE METER/ACCELEROMETER SHORT FORM KIT (contains PCB (04108111), programmed PIC micro, MMA8451Q accelerometer chip and 4 MOSFETS)	AUG 2011/NOV 2011	$44.50
TENDA USB/SD AUDIO PLAYBACK MODULE (TD896 *or* 898)	JAN 2012	$33.00
JST CONNECTOR LEAD 3-WAY	JAN 2012	$4.50
JST CONNECTOR LEAD 2-WAY	JAN 2012	$3.45
RADIO & HOBBIES ON DVD-ROM (Needs PC to play!)	n/a	$62.00
AMATEUR SCIENTIST VOL4 ON CD	n/a	$62.00

AND NOW THE PRE-PROGRAMMED MICROS, TOO!

Micros from copyrighted and contributed projects may not be available.

As a service to readers, *SILICON CHIP* is now stocking microcontrollers and microprocessors *used in new projects* (from 2012 on) and some selected older projects – **pre-programmed and ready to fly! Price for any of these micros is just $15.00 each + $10 p&p per order**

PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)	PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)	PIC18F14K50	USB MIDIMate (Oct11)
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Semtest (Feb-May12)	ATTiny861	VVA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11)	PIC12F675	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10), Ultrasonic Anti-fouling (Sep10), Cricket/Frog (Jun12)
PIC16F88-E/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11), Quizzical (Oct11), Ultra-LD Preamp (Nov11)	ATTiny2313	Remote-Controlled Timer (Aug10)
		ATMega48	Stereo DAC (Sep-Nov09)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)	PIC18F1320-I/SO	Intelligent Dimmer (Apr09)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11)	dsPIC33FJ64MC802-E/SP	Induction Motor Speed Controller (Apr-May12)

***Note: P&P is extra ($10 per order). Prices listed include GST and are valid only for month of publication of this list; thereafter are subject to change without notice.** 06/12

When ordering, be sure to nominate BOTH the micro required and the project for which it must be programmed.

SILICON CHIP Order Form

Your Name:	
Your Address:	
State:	Postcode:
Country:	
Telephone No:	Fax No:
Email Address:	

Please supply:

Qty	Item Description	Item Price	P&P if extra	Total Price
Thank you for your order.			TOTAL $A	

Payment options:

- EFT/Bank Deposit: Silicon Chip BSB 012-243 A/C 2636-80001 *Please confirm transfer by email to silicon@siliconchip.com.au or fax 02 9939 2648*
- PayPal: From your PayPal account: "Send Money" to **silicon@siliconchip.com.au**
- Cheque/Money Order/Bank Draft: payable to Silicon Chip (Australian dollars only) *Mail to Silicon Chip PO Box 139 Collaroy NSW 2097 Australia*
- Credit Card (see below; Visa and Mastercard ONLY): *Fax to 02 9939 2648, telephone 02 9939 3295 or mail or email to above address.*

If paying by Visa or Mastercard please enter your details below **(we DO NOT accept Amex, Diners or other credit cards)**

Card No: | | | | | – | | | | | – | | | | | – | | | | | Expiry Date: | | / | | |

Cardholder Name: | Signature:

To Place Your Order:

eMAIL (24/7) silicon@siliconchip.com.au with order & credit card details **OR** **FAX (24/7)** This form (or a photocopy) to (02) 9939 2648 with all details **OR** **PAYPAL (24/7)** Use PayPal to pay silicon@siliconchip.com.au **OR** **PHONE • (9-5, Mon-Fri)** Call (02) 9939 3295 with your credit card details **OR** **MAIL** This form to PO Box 139, Collaroy NSW 2097.

*ALL ITEMS SUBJECT TO AVAILABILITY. PRICES VALID FOR MONTH OF MAGAZINE ISSUE ONLY. ALL PRICES IN AUSTRALIAN DOLLARS AND INCLUDE GST WHERE APPLICABLE. 06/12

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Write to: Ask Silicon Chip, PO Box 139, Collaroy Beach, NSW 2097 or send an email to silicon@siliconchip.com.au

Bed pan machine is a pain in the . . .

I am an electrical engineer at Ipswich Hospital in the UK. I wonder if you could give me some advice. We have problems occasionally with the timing chip (picture attached to email) from a bed pan machine. Basically it times pumps, solenoids and motors.

Unfortunately, the timing chip goes wrong on a regular basis and we have no option but to purchase a new board which costs £300. Is there a way or company to duplicate these chips in the UK? (M. E., Ipswich, UK).

● It seems highly likely that the IC is a micro and the label on it refers to the version of software it is programmed with. If you peel off the label, you may be able to identify what type of micro it is. However, the software is likely to be in flash memory and so it is unlikely that you could get the chip duplicated.

The question you should be asking of the suppliers is "why do these modules keep failing?" Is there no warranty? It may also be possible to compare voltages etc with a known good module. If the micro keeps failing, perhaps it is being hit by voltage spikes on its supply or input leads.

If you can trace out the circuit, you might be able to add diode clamping to particular inputs and also ensure that the power supply itself does not cause the failures.

Alphanumeric clock tells the time in English

I was in Singapore recently and saw this cool-looking clock in action. My first thought, "What a great idea for a project!". See it at **http://store.biegertfunk.com/us/collection-qlocktwo.html** What do you think? (T. R., via email).

● As you say, that clock idea looks pretty neat. But SILICON CHIP actually did the same thing 18 years ago, back in November 1994, with a PIC16C57 driving LED dot-matrix displays. It gave the same sort of readouts such as 10 past 8, 6 o'clock, midnight and noon.

Providing a source of 120VAC at 60Hz

My son and daughter-in-law have recently inherited a 60-year-old model steam train that originated from the USA. To rejuvenate this model, they purchased spare parts and two new model train sets from the original manufacturer in the USA. These model train sets are powered via a control transformer from 120VAC 60Hz/18VAC at about 80W for each loco.

The control transformer produces sequenced outputs that synchronise bells, whistles, voice announcements, engine reverse etc. Having access to only 120VAC at 50Hz, these sequenced outputs are out of sync. Could you suggest a source of 230/120VAC 60Hz at about 200W that does not involve the purchase of a petrol-powered generator from the USA? (M. O., Wyndham, WA).

● We assume that the model locomotive was made by Lionel or one of the big model O-scale train makers of the time. Their system for generating bells and whistles was quite intriguing but as you say, it did depend on a 60Hz mains supply.

Unfortunately, there is no easy solution to your problem. One possible way would be to feed a 60Hz sinewave into an audio amplifier to produce an output of 18VAC. This could be substituted for the transformer in your 120VAC train power supply to run the bells, whistles etc.

For example, you could use an SC480 100W amplifier module as described in the November 2009 issue. Its output voltage is adjustable and it has a 70V line output which should be more than adequate for your application.

Modular Solar Power System Proposal

I'd like to see a design for a modular solar system to recharge a battery during the day and provide 230VAC power to a single 10A outlet continuously. The system would need to be modular enough to allow for different loads, eg, it might be used for only a few hours in the evening to run a 60W lamp or it might run a 450W computer power supply or a full 10A load continuously.

I do understand that you can't make a one-size-fits-all system, which is why I suggest a modular design, so the builder can decide the balance; large battery and high-amp solar array or smaller battery and/or lower amperage array? It depends on how much sun you expect in your area and how much risk you're willing to take on running out of power.

It would be nice (but not essential) if you could include an option for the system to automatically switch over to house power from a standard outlet if the battery gets too low. (J. W., Bairnsdale, Vic).

● What you are proposing is actually three separate systems, with major differences between numbers of panels, battery bank and inverter rating. In fact, the system to run a 10A load continuously (2300W) would be very large and expensive.

And why would you want to run a 450W computer power supply? If you have such a computer which needs this huge amount of power, it may be time to update. For example, we recently installed a new server with four 1TB drives. It draws an average of 60W. It would not have enough computing grunt to be a super games machine, though.

As an alternative, where you have to run on solar power, a late-model laptop PC can be a very efficient choice.

scribed in the January and February 2003 issues. However, we would not regard this an easy or simple solution.

Nor would the purchase of a petrol-powered generator from the USA be a good solution. The frequency accuracy and stability of such generators is quite unpredictable and tends to vary markedly with the load. A better solution might be to obtain a 12V DC to 120VAC 60Hz sinewave inverter. This could be powered from a 12V car battery or a standard PC power supply.

Query on fluorescent lamp starters

Many years ago a magazine (probably *Electronics Australia*) featured an article on constructing an electronic starter switch for fluorescent lamps – you know, the little white cased thing that pre-heats the filament and then helps generate the spike to start the lamp.

Before I could make one, Jaycar (or was it Dick) offered a made-up unit for sale. I bought one and have been delighted. Tube life is phenomenal and light up is instant. I want more but have lost the magazine and no-one knows what I am talking about. Can you help? (M. S., Narrogin, WA).

● We described an electronic starter for fluorescent lamps in the August 1996 issue, featuring a Philips UBA200T chip. The chip should still be available but we do not have the PCB. However, we would not recommend that you build the device. Electronics starters can be purchased from some hardware stores and lighting outlets.

Better still, have a look at the Circuit Notebook pages in the May 2012 issue. They describe how the electronic driver from a CFL can be used as an electronic ballast for a standard fluorescent lamp. It not only provides flicker-free turn-on but its higher frequency operation means that the tube is brighter and overall efficiency is improved.

Amplitude of S-video luminance signal

An S-video socket has four pins; two are for the luminance signal and two for the chrominance signal.

Does the luminance signal also contain horizontal, vertical and probably the colour-burst sync signals? If the luminance signal does include sync, is it a standard video signal of 1.4V at 70 ohms? (P. C., Carnegie, Vic).

● The luminance signal does carry the sync and colour burst signals. With a peak-white signal, the amplitude is 1V peak-peak, the same as a standard composite video signal.

Running the 10W LED spotlight at 6V

I would really like to run the 10W white LED spotlight (SILICON CHIP, February 2012) on 6V rather than 12V. Is this possible? (J. W., via email).

● Three white LEDs in series require more than 10V and you cannot rewire the LEDs on the chip so the answer is no; you cannot run it from 6V.

Transistor substitute for Programmable Ignition

I am interested in building the Programmable Ignition System from March-May 2007.

In the article, you outline a schematic for an ignition coil driver which includes a BU941P Darlington transistor which is protected from voltage spikes using a string of four 75V 1W zener diodes. I couldn't find the BU941P transistor but Element14 sell a BU941ZP which appears to be a replacement and it includes an integral protection zener. The datasheet can be seen at: **http://www.datasheetcatalog.org/datasheet/stmicroelectronics/1008.pdf**

If this part is used, is it safe to assume that the string of zener diodes can be omitted? (T. R., via email).

● Yes, you can omit the four 75V diodes. No other changes are necessary.

Auto-transformer for 120VAC

I have an idea that could be published in the Circuit Notebook pages. Many electronic products that operate on 120VAC are being purchased on the net from the USA but they need a source of 120VAC. I recently made an auto-transformer from two identical mains transformers that I found in a bargain bin from one of the local suppliers.

It involves connecting the primary windings in series and the secondary windings in parallel. The primary windings can then be configured as an auto-transformer. (J. C., via email).

● It is an interesting idea but one that simply cannot work, except maybe with very light loads.

For a start, if you are merely going to use the primaries of two identical transformers in series to tap off 120V,

Questions On The Motor Speed Controller

With respect to the circuit of the Induction Motor Speed Controller published in the April & May 2012 issues, if the IGBT module logic is powered up slightly after the 340V DC bus appears, as may in fact occur, then there would be no logic control over the IGBTs, potentially risking the module or at least the fuse and circuit breaker. Is this a problem?

Also what about the possibility of incorporating a braking resistor and control system to stop DC bus over-voltage when using the speed control with a lathe motor? (R. H., via email).

● The IGBT module includes in-built under-voltage lock-out on all of the IGBT drivers, so there is no danger of the IGBTs switching unexpectedly, regardless of the state of the logic signals. The IGBTs are held off until the drive power supplies reach the proper levels. On top of this, the module includes "shoot-through" protection to ensure that high-side and low-side switches can never be on at the same time – in fact it provides for a small "dead-time" between them.

It is certainly possible to use a braking resistor which is switched across the DC bus if high-inertia loads must be decelerated quickly. However, it is a relatively expensive proposition; another 600V 20A IGBT, plus drive and protection circuitry, and a kW-rated, high-voltage resistor with associated mounting and cooling headaches.

It is only necessary when it is not safe or feasible to decelerate the motor over a long period. The current design offers a deceleration period up to 30 seconds which should be adequate for most loads.

Delusions Of Sound Quality Improvement On The Ultra-LD

I have downloaded and read with great interest your articles on the Ultra-LD Mk.3 amplifier and upgrade from Mk.2. I have a couple of comments and some questions.

I was very disappointed with the Mk.2 amplifier sound quality as I had already built your April 1996 amplifier design from a Jaycar kit and it sounds better than the Ultra-LD Mk.2 in my tests. I managed to raise the sound quality to nearly that of the 1996 design by replacing the 12kΩ feedback resistor with a 10kΩ bulk-foil version. I have made similar upgrades on other amplifiers previously and never been disappointed; it has always improved the sound quality. I had some 10kΩ bulk foil resistors already so I used this instead of a 12kΩ resistor.

I suggest this modification is also tried by others on both the Mk.2 and Mk.3 to improve the sound quality massively; it may also be worth replacing the 510Ω resistor attached here too.

I can't wait to complete the upgrade to Mk.3 on my amplifier and hope it will then sound at least as good as your April 1996 design. During sound quality tests I will also remove the bulk foil resistors so I can compare a standard Mk.2 and Mk.3 sound quality (I hope to hear a massive difference).

I can't seem to find a full kit of parts for the Mk.3. Do you know of any suppliers as I wish to build a surround sound version for my son. Thanks for your excellent designs and honesty about the failings of the Ultra-LD Mk.2; just as it should be, honest and as it really is.

I have also made two of your Studio Series Preamps with headphones and Alps motor pots; fantastic sound, difficult to beat at any price. It's best to build an earthed metal shield around the relays to reduce noise though. (R. P., Horley, UK).

- While your Ultra-LD Mk.2 may possibly not sound as good as the Plastic Power amplifier from April 1996, the idea that changing a single resistor makes all the difference is just ridiculous. If your Ultra-LD sounds poor then it is possible that you have one or two low-spec transistors. This does happen. But if this was the fault, changing the feedback resistor would not make the slightest difference.

For the record, the performance of all of the Ultra-LD series amplifiers is superior to the Plastic Power design and you can see the distortion figure comparisons for the Ultra-LD Mk.2 & Mk.3 designs in the July 2011 issue. That is not to say that the Plastic Power amplifier was a bad design; it was good at the time. But that was then and now we can do better and much of the improvement has come about from improved layout of the PCBs.

Yes, we have seen the stuff on the internet where people claim that when they change to bulk-foil resistors the sound suddenly improves. Well, here we go again as we must dismantle yet another in a long (seemingly inexhaustible) line of audio myths. So what are the wonderful attributes of metal foil resistors?

They are very close tolerance, very stable (ie, they don't change their value), they have low noise and they have a very low temperature coefficient. These are all good characteristics but in the vast majority of audio designs none of these make the slightest difference in performance or sound quality when compared to exactly the same circuits which use metal-film resistors.

The most important parameter that could make a difference in sound quality in the 12kΩ feedback resistor is the temperature coefficient. If the TC was poor (high), the feedback resistor could change its value over the course of a single output excursion due to the differing self-heating as the output voltage and thus dissipation in the resistor changes. If this effect was large enough to cause distortion, we would see it in our measurements; the relatively low dissipation (90mW at full power) and the resistor's thermal inertia mean the change in value is negligible with a standard metal film resistor. If foil resistors did make a difference, we would definitely specify them.

That is really the end of the story but we must reiterate a point that we have made many times before. It is simply futile for any audio enthusiast to make circuit changes unless he or she has the equipment to measure the effect of such changes. In our experience, virtually all changes made in this way actually degrade performance.

And anyone who makes assertions about improvements to sound quality on the basis of a simple "before and after" listening test is probably suffering from delusions. At the very least, if listening tests are made they must be "blind" whereby the person doing the listening comparison does not know which "source" he or she is listening to. Better still are "double-blind" tests whereby the person running the test (ie, switching the "sources"), does not know which source is being listened to.

Such tests are very difficult to do properly because such things as gain, frequency and phase response must all be very closely matched otherwise very slight differences in gain etc can easily lead to the conclusion that the slightly louder device is the better one.

Here ends the diatribe. We understand that Altronics (**www.altronics.com.au**) will ultimately have a kit of parts for the amplifier.

that means that the primary of the top transformer must be able to provide the full load current of the 120VAC device. This may be OK for a low-power appliance but is unworkable for higher power. There would also be no point in connecting the transformer secondary windings in parallel as they perform no function in the auto-transformer action. And if you get the parallel connection wrong, both transformers will burn out.

Secondly, many 120VAC appliances simply would not withstand the stresses of connection to our 230VAC mains supply even if they only have 120VAC applied from an autotransformer. The danger is that unless the wiring is correct, the 120VAC appliance may have 230VAC applied between its wiring and any metalwork. So there is defi-

Retro-fitting A Heated Oxygen Sensor

I want to install a heated oxygen sensor into my Land Rover Discovery. However, the ECU and the vehicle were never produced with oxygen sensors.

Is there a PCB for controlling the heated element inside the oxygen sensor? Can one be made up to simply check for temperature and supply voltage when needed?

I do have a 1-wire sensor installed, however I would like a heated one to perform more accurate tuning. (M. M., Croydon South, Vic).

● Narrowband oxygen sensors often do have heater elements, however, they are really only useful for detecting stoichiometric ratios due to the sharp change in voltage as the mixture becomes slightly rich or lean from stoichiometric. Outside stoichiometric, the sensor voltage does not accurately measure air/fuel ratios that are rich or lean.

A wideband sensor, however, is suitable for accurate measurements of air/fuel ratios that are rich or lean as well as stoichiometric. It can be used in place of a standard narrowband sensor but requires a controller. Have a look at the first article on the Wideband Oxygen Sensor Controller in this issue. It is the deluxe answer for your application.

nitely a fire or shock hazard.

Third, the idea is probably not workable if the said 120VAC appliance contains an induction motor because our 50Hz grid may not suit 60Hz motors or the resultant speed will be wrong. A similar comment may apply to the 120VAC transformer in the appliance itself.

Keeping the worst until last, you cannot simply wire the primaries or other windings of two transformers together and hope that they will work as an auto-transformer. For that to happen, the windings need be immersed in a common magnetic flux. That cannot happen when you have two separate transformers.

Using a bright LED in a slide projector

I have hundreds of colour slides dating back to 1950 that I would like to examine with a projector. Unfortunately, my old ALDIS 240VAC machine runs extremely hot after a few minutes, as I found out the hard way.

Could you advise me if there is a super-bright Star LED module available that would work as a replacement lamp in the projector? The projected image does not have to light up the far wall. A range of about two metres would be enough to view the image.

If a Star LED will work OK could you advise me what units of electronic equipment etc I would need to purchase? (B. S., via email).

● Have a look at the LED Dazzler project in the February 2011 issue. One 10W LED would probably suffice but it will need to be mounted on a heatsink. We assume that your projector is fan-cooled so the heatsink might not have to be very big.

Electronic substitute for centrifugal start switch

In regards to the Induction Motor Speed Controller presently being described, for single phase motors with start switches, would it not be possible the replace the centrifugal start switch with an electronic switch which does the same job, ie, after a pre-determined time the switch would turn off and stay off until such time as the power to the motor was turned off?

Would these motors then have the same torque at low speeds as at normal speed with this arrangement? (J. B., Charlestown, NSW).

● Your suggestion is certainly feasible but we would be reluctant to do it since it would be necessary to modify the wiring of the motor and then install the additional circuitry in an external box.

Two and 3-wire reluctor question

I am in need of some information or advice on the reluctor version of the Programmable Ignition system (SILICON CHIP, March, April & May 2007). The reluctor referred to in your articles is a 2-wire magnetic pickup but mine has three wires.

By my understanding, two wires means a sinewave and three is a square-wave signal. Do I use the Hall effect version of the kit in this scenario? Or is there no allowance for my application? (R. W., via email).

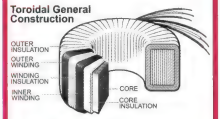
● A reluctor delivers an AC signal which is generated in a coil that has two wires. Some reluctors do have a connection to chassis. A sensor with three wires is possibly one that has a processed signal where a supply is required or the sensor may have a power transistor to directly drive the ignition coil.

You would need to find out what the wires are normally connected to and what type of signal the sensor delivers. This should be possible by turning over the motor to check for an AC signal from two of the wires. It is not recommended to connect any of the three wires to a supply if the sensor requires this unless the wire connections and required voltage are known.

If the 3-wire sensor requires a supply and has a digital output, then the Hall effect configuration may be suitable. If the sensor has an integrated transistor for directly driving the ignition coil, then the points version might be better where the points input

ANTRIM TRANSFORMERS
manufactured in Australia by
Harbuch Electronics Pty Ltd
harbuch@optusnet.com.au

Toroidal – Conventional Transformers
Power – Audio – Valve – 'Specials'
Medical – Isolated – Stepup/down
Encased Power Supplies



Comprehensive data available:
www.harbuch.com.au
Harbuch Electronics Pty Ltd
9/40 Leighton Pl, HORNSBY 2077
Ph (02) 9476 5854 Fax (02) 9476 3231

Speedo Corrector Gives Intermittent Reading

I have purchased five Speedo Corrector kits (Jaycar KC5435) to be used in a limited vehicle production to overcome an original equipment manufacturer problem. The vehicle speedo needs to be clocked faster than the incoming frequency from the axle so this kit is ideal.

They work perfectly well except for a randomly occurring problem. Just when taking off (1 in 20 times) the Speedo Corrector sends out a trail of pulses and the speedo "runs" around to 160km/h and returns to zero and then indicates vehicle speed. I have tried filtering the incoming and outgoing pulses but it is no different.

Is it possible to have a software update in the PIC chip to eliminate this problem? (J. B., via email).

● As far as we are aware, there is no software problem that causes the random high-frequency signal burst.

Instead, the incorrect reading could possibly be corrected by increasing the capacitor at the input (ie, across the collector and emitter of transistor Q1) from 1nF (code 102 or 1n0) to 10nF (code 103 or 10n). On the PCB, this is the capacitor just above the 150Ω resistor that is above IC1.

If the problem persists, try a 47nF (473 or 47n) or 100nF (104 or 100n) capacitor instead.

is the output transistor from the sensor.

Either way, the Programmable Ignition does cater for the signal from your sensor once the wire connection requirements/output are determined.

Boat projects wanted

I love your projects and your DIY style. Have you ever considered doing marine projects such as depth finders, GSP locating mapping auto pilot, rudder angle indicator, fuel consumption and smart chargers? There is a hole that other main-stream magazines forget.

Keep up the good work. (J. S., Shelton, Ct, USA).

● We have produced a number of boat projects, as follows:

(1) Twin-Engine Speed Match Indicator, November 2009.

(2) Ultrasonic Anti-fouling For Boats, September & November 2010.

(3) GPS Boat Computer/Navigator, October 2010.

(4) Rudder Position Indicator, July & August 2011.

We can supply back issues for $AUD15.00 each including airmail P&P (outside Australia).

Fault in digital thermometer

I have purchased the kit for the High Temperature Digital Thermometer (Silicon Chip's Performance Electronics for Cars, 2004; Jaycar KC-5376). My intent was to measure exhaust gas temperature and you advertise your device is capable of doing that. However, after soldering everything into place the device has never worked correctly when measuring high temperatures.

After calibrating the device it seems to perform more or less OK when measuring temperatures up to 100°C. But when I try to measure the temperature of the exhaust gases the reading of the temperature on the LCD starts rising and when it reaches somewhere around 300°C, the rising of the temperature stops for a second, and then the reading of the temperature starts going down and goes below zero, eventually showing negative temperatures although the real temperature is a few hundred degrees Celsius.

But again, when measuring up to around 100°C it seems to work OK. Whatever I do, it is always like that. I believe I connected the LCD correctly and also connected 9 pin to pin 10 and 5 pin to pin 8 on the LCD. My thermocouple is specially designed to measure exhaust gas temperatures. (M. E., via email).

● When used to connect to the exhaust of a vehicle, the thermocouple probe needs to be an insulated type. An earthed probe will cause the thermocouple to be grounded and the readings will be affected.

Either ensure an earthed probe is insulated electrically from the exhaust pipe or use an insulated probe. Use of an insulated probe is mentioned in the parts list and text under the "fitting" sub-heading.

You can test if your probe is earthed by measuring the resistance between the probe and one of the thermocouple connections. An earthed probe will show close to zero ohms, while an insulated probe will show a high impedance above 1MΩ.

We should also note that your probe could have a fault whereby it goes open circuit at temperatures above 300°C.

Incidentally, the High Temperature Thermometer/Thermostat described in the May 2012 issue of Silicon Chip is a similar project but with improved

continued on page 104

WARNING!

Silicon Chip magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of Silicon Chip magazine.

Devices or circuits described in Silicon Chip may be covered by patents. Silicon Chip disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. Silicon Chip also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

Advertisers are warned that they are responsible for the content of all advertisements and that they must conform to the Competition & Consumer Act 2010 or as subsequently amended and to any governmental regulations which are applicable.

MARKET CENTRE

Cash in your surplus gear. Advertise it here in SILICON CHIP

ELNEC IC PROGRAMMERS

High quality
Realistic prices
Free software updates
Large range of adaptors
Windows 95/98/Me/NT/2k/XP

CLEVERSCOPE USB OSCILLOSCOPES

2 x 100MSa/s 10bit inputs + trigger
100MHz bandwidth
8 x digital inputs
4M samples/input
Sig-gen + spectrum analyser
Windows 98/Me/NT/2k/XP

IMAGECRAFT C COMPILERS

ANSI C compilers, Windows IDE
AVR, TMS430, ARM7/ARM9
68HC08, 68HC11, 68HC12

GRANTRONICS PTY LTD

www.grantronics.com.au

Battery Packs & Chargers

Siomar Battery Engineering
www.batterybook.com
Phone (08) 9302 5444

Circuit Ideas Wanted

Do you have a good circuit idea? If so, sketch it out, write a brief description of its operation & send it to us. We pay up to $100 for an original circuit so send your idea to:

Silicon Chip Publications,
PO Box 139, Collaroy, NSW 2097.

SPLat CONTROLS **Tough times demand innovative solutions!**

In tough economic times you need to watch every dollar. SPLat embedded controllers give OEMs more functionality per dollar than any competing product. Check out our website today and discover how we can help you remain competitive.

Made in Australia, used by OEMs world-wide

splat-sc.com

Printed Circuit Board Manufacture

48-Hour service • High quality • Low prices
1 offs to any quantity
Artwork design if required
Call for obligation free quote...
INSTANT PCBs, POBox 448, Avalon 2107
Ph (02)9974 1189 Fax (02)9974 5491

FOR SALE

PCBs MADE, ONE OR MANY. Any format, hobbyists welcome. Sesame Electronics Phone (02) 8068 2713. **sesame@sesame.com.au www.sesame.com.au**

LEDs! Nichia, Cree and other brand name LEDs at excellent prices. LED drivers, including ultra-reliable linear driver options. Many other interesting and hard-to-find electronic items! **www.ledsales.com.au**

PCBs & Micros: Silicon Chip Publications can supply PCBs and programmed micros for recent (and some not so recent) projects described in the magazine. Phone (02) 9939 3295 or email **silicon@siliconchip.com.au**

questronix.com.au – audiovisual experts solve home, corporate security and devotional installation & editing woes. QuestAV CYP, Kramer TVone (02) 4343 1970 or **sales@questronix.com.au**

WANTED

CUSTOMERS WANTED: Truscotts Electronic World – large range of semiconductors and passive components for industry, hobbyist and amateur projects including Drew Diamond. 27 The Mall, South Croydon, Melbourne. Phone (03) 9723 3860. **www.electronicworld.com.au**

KIT ASSEMBLY & REPAIR

KEITH RIPPON KIT ASSEMBLY & REPAIR:

- Australia & New Zealand;
- Small production runs.

Phone Keith 0409 662 794. **keith.rippon@gmail.com**

GEOFF COPPA KIT ASSEMBLY AND TROUBLE SHOOTING SERVICE. Phone Geoff on 0414226102. **coppamitchell2@bigpond.com**

ADVERTISING IN MARKET CENTRE

Classified Ad Rates: $29.50 (incl. GST) for up to 20 words plus 85 cents for each additional word. Display ads: $54.50 (incl. GST) per column centimetre (max. 10cm). Closing date: 5 weeks prior to month of sale. To book, email the text to **silicon@siliconchip.com.au** and include your name, address & credit card details, or fax (02) 9939 2648, or phone (02) 9939 3295.

RFMA RF Modules Australia
Low Power Wireless Connectivity Specialists

USB BLUETOOTH
PARANI UD100-G01
Class 1 Bluetooth 2.0+EDR
Working distance to 300m
Toshiba or BlueSoleil driver
Optional 5dBi Dipole Antenna

Applications:
Rural
Utilities
Industrial
Commercial
Government
Meter Reading

CONNECT TO YOUR SOLAR INVERTER THE EASY WAY!

RF Modules Australia. P.O. Box 1957 Launceston, TAS., 7250.
Ph: 03-6331-6789. Email: sales@rfmodules.com.au. Web: rfmodules.com.au

Ask Silicon Chip
. . . continued from p102

circuitry based on an Analog Devices AD8495 precision instrumentation amplifier.

MPPT operation misunderstood

According to the schematic supplied for the MPPT Solar Charge Controller in the March 2012 issue, there is no voltage conversion that is characteristic of a MPPT controller. I believe it is not really an MPPT device. Just having a bit of smarts does not qualify. (J. H., via email).

● The MPPT operation of this project was fully explained in the first article, in the February 2011 issue. The voltage conversion is done by switching the Mosfet at 31.25kHz under the control of the micro. There is a brief mention of this PWM (pulse width modulation) in the caption of the circuit diagram on page 92 of the March 2012 issue.

So the microcontroller is actually providing two functions: MPPT for the solar panel and 3-stage charging for the battery. If you would like a copy of the February 2011 issue, we can supply it for $12 including postage and packing. SC

DOWNLOAD OUR CATALOG AT
www.iinet.net.au/~worcom
WORLDWIDE ELECTRONIC COMPONENTS
PO Box 631, Hillarys, WA 6923
Ph: (08) 9307 7305 Fax: (08) 9307 7309
Email: worcom@iinet.net.au

Notes & Errata

Ultra-LD Mk.3 200W Amplifier Module, Pt.2 (August 2011): the Dynamic Headroom specification was calculated incorrectly. It should be 1dB for 8Ω loads and 1.3dB for 4Ω loads. The Music Power and Slew Rate figures are correct.

USB MIDIMate (October 2011): the 18-pin IC socket specified in the parts list should be a 20-pin IC socket.

Crystal DAC (February 2012): the original PCB has the trimpots rotating in the opposite direction to that stated in the article, ie, clockwise rotation decreases the quiescent current rather than increasing it. A modified PCB file has been uploaded to the website which fixes this problem. Constructors using the original PCB should rotate both trimpots fully clockwise before applying power for the first time.

1.5kW Induction Motor Speed Controller (April-May 2012): the PCB overlay diagram (May, p69) shows two 270Ω resistors below IC3 which should have been labelled 100Ω (their value is wrong in the parts list too). Also, the circuit diagram (April, p22) shows the three pull-up resistors for the pins of CON5 (two 4.7kΩ & one 1.5kΩ) all connected to pin 1 of CON4. They are actually connected to the +3.3V rail.

Finally, the Altronics catalog number for the 470µF 400V capacitors in the parts list is incorrect. It should be R5448.

Advertising Index

Altronics ..... loose insert
Dyne Industries 7
Embedded Logic Solutions 8
Emona Instruments 11
Geoff Coppa 103
Grantronics 103
Harbuch Electronics 101
Hare & Forbes ..... OBC
Instant PCBs 103
Jaycar IFC,49-56
Keith Rippon 103
Kitstop 45
LED Sales 103
LHP.NET.AU ..... IBC
Microchip Technology 15
Mikroelektronika 23
Oatley Electronics 31
Ocean Controls 6
Quest Electronics 103
Radio & Hobbies DVD 45
Reality Design 7
Red Button Technologies 5
RF Modules 104
Roc-Solid 9
Sesame Electronics 103
Silicon Chip Binders 72,103
Silicon Chip Bookshop 88
Silicon Chip Order Form 97
Silicon Chip Partshop 96
Silicon Chip Subscriptions 89
Siomar Battery Engineering 3,103
Splat Controls 103
Truscotts Electronic World 103
Verbatim Lights 81
Wiltronics 10
Winradio Communications 25
Worldwide Elect. Components 104

INFOMON SOLAR

Infomon solar panels are the perfect choice for those who demand exceptional performance and quality. Folding solar panel kits include a carry bag, battery charge controller and cable with alligator clips.

FIXED

20W	$49
50W	$99
80W	$180
100W	$230
120W	$250
200W	$499

FOLDING KIT

60W	$150
80W	$199
100W	$299
120W	$350
160W	$488
200W	$499

240VAC INFOMON PURE SINEWAVE SILENT INVERTER GENERATOR

2KVA was $1599 **now $499!**
3.5KVA was $1899 **now $799!**

PORTABLE FRIDGE FREEZER

FREE BONUSES: insulation cover, wall charger & 12v cigarette adaptor. **REDUCED!**
45L was $1499 NOW $499
80L was $1899 NOW $599

REVERSING CAMERA KIT

Includes all connection cables, 7" monitor, remote & IR camera
was $189 **REDUCED TO (wireless kit: $199) $99!**

CCTV CAMERA

IR NIGHT VISION WATERPROOF COLOUR
$20

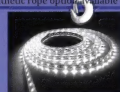
10.2" ANDROID TABLET

$199!

ELECTRIC WINCH

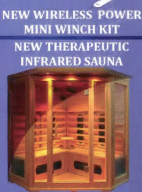
12000 lbs wireless remote **$499!**
synthetic rope option available $799

$189! NEW WIRELESS POWER MINI WINCH KIT



12vdc LED Bright Lights

5m strip, cuttable to length **$49**



NEW THERAPEUTIC INFRARED SAUNA

WAS $2599
NOW ONLY $999

125cc

$499

$899

INFOMON WIND TURBINE

One of the most advanced wind turbines to generate some serious power, sold as a 1kW or 2kW complete kit with a stand & rectifier.
LIMITED STOCK!
1kW $899 2kW $1999

12V DC to 240V AC +USB POWER INVERTER 1kW reduced to $99!

Also available in 150w & 1000w.

1.5KW SOLAR GRID INVERTER

CEC APPROVED
Other sizes also available. **$499**

BATTERY CHARGE CONTROLLERS

wide range from **$35!**

150 PSI Heavy Duty AIR COMPRESSOR

150L/min **$99!**

EXHAUST/HI LIFT JACKS

starting from **$99**

HEATED HYDRO THERAPY SPA

- Computer control touch pad (60+ jets)
- Complete with pumps, filtration system
- Radion heater + recliner head rests
- Available in modern white interior polish
- **100% AUSTRALIAN OWNED company**
- **100% AUSTRALIAN APPROVED**

WAS $8899
CLEARANCE SALE $3899

www.lhp.net.au
02 9620 9011

WWW.LHP.NET.AU - 02 9620 9011

END OF FINANCIAL YEAR SALE!

THREAD REPAIR KIT

- Metric (M5x0.8mm, M6x1.0mm, M8x1.25mm, M10x1.5mm, M12x1.75mm)
- 130 pieces set

SAVE $14.90

$149 (T100)

RE-THREADING TAP & DIE KIT

- 42 piece metric, UNC, UNF
- All taps & dies are hex shaped for use with a socket or wrench
- Contents: covering all M6-M12, 1/4"-5/8" coarse & fine thread
- Includes 2 thread files

SAVE $10.90

$89 (T092)

DIGITAL BEVEL BOX

- Digital readout display
- 3 embedded disc magnets on base
- 0.1 degree resolution
- 180° range

$62 (M977)

DIGITAL ANGLE GAUGE

- Absolute & incremental
- Zero button
- 360° range

SAVE $12.50

$59 (M978)

MAGNETIC BASE & METRIC DIAL INDICATOR

- Magnetic base with on/off switch
- Metric dial
- 0-10mm dial indicator
- Comes in a blow mould case

SAVE $11

$66 (M059)

DEGREE PROTRACTOR

- 150mm rule length
- 0-180° range
- Brass lock nut
- Stainless steel

$25 (D801)

ENGINEERS SQUARES

- Hardened & polished spring steel blades
- True right angle inside & outside
- BSS:939 Grade "B"

BLADE	STOCK	
75mm	60 x 8mm	$25 (D644)
100mm	75 x 11mm	$35 (D645)
150mm	100 x 14mm	$39 (D646)
225mm	140 x 18mm	$59 (D647)

SPRING CALIPERS

DIVIDERS	$9 (D634)
INSIDE	$9 (D635)
OUTSIDE	$9 (D636)

SCREW PITCH THREAD GAUGE

- 28 x imperial threads
- 23 x metric threads
- 1 x 60° screw cutting gauge

$14 (D610)

FEELER GAUGE

- 0.03-1.0mm thickness range
- High grade tool steel
- Hardened tempered & polished

$16 (D616)

DIAL CALIPERS

Range	Graduations	
0-6"	0.001"	$89 (D190)
0-150mm	0.02mm	$89 (D191)
0-200mm	0.02mm	$129 (D192)

PIN PUNCH SET

- 6 piece pin punches (tip diameter x shaft hex x length)
- Ø3 x 10 x 150mm
- Ø4 x 10 x 150mm
- Ø5 x 10 x 150mm
- Ø6 x 10 x 150mm
- Ø7 x 12 x 150mm
- Ø8 x 12 x 150mm

$18 (P365)

FLEXIBLE HEAD TELESCOPIC MAGNETIC PICK UP TOOL

- 3 x LED lights
- Flexible head
- Extends 170 - 545mm
- Magnet can carry 2.27kg's

$18 (TB501)

TAP & DRILL SET 29 PIECE - METRIC SET

- M3, M4, M5, M6, M8, M10 & M12 Taps (3 taps per size)
- HSS
- Includes drill to suit each size tap

$69 (TD158)

BENCH VICES

- Acme screw thread
- Cast iron

Size		
100mm	$55 (V098)	
127mm	$89 (V099)	
152mm	$119 (V090)	

VICE BRAKE BENDER

- Sheet metal bender
- Bends up to 2mm thick mild steel
- Strong magnets hold die & knife to vice jaws
- Segmented blade

Size	
100mm x 2mm	$35 (V050)
125mm x 2mm	$45 (V051)
150mm x 2mm	$54 (V052)

22 or 35 WATT WORK LIGHTS

- Fluorescent tube with 5X mainify
- 3 x pivot arm
- 3 x LED's
- Flexible arms

22 watt $139 (L2662)

35 watt $129 (L2814)

JOBBER DRILL SET HSS

- 1 - 6mm range
- 0.1mm increments
- 51 piece set
- Precision ground flutes
- 118° split point

SAVE $10

$89 (D1285)

CARBIDE BURR SET

- 1/4" x 6" shank diameter x length
- SD-3, SD-5, SG-5, SC-5, SF-5
- Double cut burrs

SAVE $10

$89 (B909)

SBD-20B BENCH DRILL

- 1hp 240V motor
- 16 spindle speeds
- 2MT spindle taper
- 16mm drill capacity
- 170mm throat depth
- Slotted work table
- Table tilts left & right to 45° & rotates 360°

SAVE $17

$269 (D138)

ORDER NOW!

USE PROMO CODE: CIRCUIT
TO RECEIVE THESE SPECIAL PRICES
ONLINE OR INSTORE! Valid until 30-06-12

Specifications & Prices are subject to change without notification. All prices include GST and valid until 30-06-12

HARE&FORBES MACHINERYHOUSE

NSW	QLD	VIC	WA
(02) 9890 9111	(07) 3274 4222	(03) 9212 4422	(08) 9373 9999
1/2 Windsor Rd, Northmead	626 Boundary Rd, Coopers Plains	1 Fowler Rd, Dandenong	41-43 Abernethy Rd, Belmont

www.machineryhouse.com.au